THE IMPACT OF HOUSEHOLD AND COMMUNITY LEVEL ENVIRONMENTAL FACTORS ON INFANT AND CHILD MORTALITY IN RURAL KENYA

by

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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ABSTRACT

This study attempts to determine the impact of household and community level environmental factors on infant and child mortality in rural Kenya. A broader definition of environment is used in this study to include the physical conditions that affect the child in the household (such as quality of household water, sanitation and housing) and in the community (such as malaria prevalence, type of treatment commonly provided to sick children, levels of protection against diseases by way of immunization, breastfeeding and nutrition). The broad study hypothesis derived from the literature reviewed is that both household and community levels environmental factors have significant impact on infant and child mortality. The specific study hypotheses were formulated and tested being guided by the analytical structure derived from Mosley and Chen (1984) conceptual framework for studying child survival in developing countries but with a slight modification to cater for incorporation of the community level contextual factors.

The formulated study hypotheses were tested using the dependent variable defined as the risk of death for children aged under five years segmented into six age intervals to cater for differentials in infant and child mortality pattern by age. In order to control for the effects of other factors that affect infant and child mortality not classified in this study as environmental, other groups of factors classified as maternal proximate variables and socio-economic variables were included in the analysis as the independent variables in addition to the environmental variables. Proportional hazards regression in log-linear format was used in this study as the main method of data analysis although other methods such as life table analysis were also used to study the differentials in infant and child mortality by categories of the environmental and other variables included in the study. The 1989 Kenya Demographic and Health Survey data restricted to 5826 children born since January 1st, 1983 by the ever married women respondents in the survey and living in 326 rural clusters served as the basic data set. The community level environmental variables were computed from 6220 children born to ever and never married women in these 326 clusters. Data on 3444 children aged 5 to 60 months in the 326 rural clusters gathered in the 1987 Rural Nutrition Survey were used to compute community level nutrition variables. Overall, the data were assessed and found to be of good quality.

At the household level, the results of the bivariate analysis established that better toilet facility, better quality of housing floor, and less contaminated water have statistically significant negative association with the risk of infant and child mortality. The study data reject the study hypothesis regarding the association between household crowding and infant and child mortality. After controlling for other factors in the full multivariate model used, better quality of housing floor was found to have a statistically significant protective effect at 99% confidence level. Children in households with modern floor quality have mortality risks estimated at about 61% lower relative to those in the worse-off category. Better toilet facility has a protective effect on risk of infant and child death although it is not statistically significant after controlling for other factors.

At the community level, the results of the bivariate analysis established that communities where malaria is not endemic, where mean breastfeeding durations exceed 15 months, and where immunization coverage exceed 67% have statistically significant negative association with the risk of infant and child death. Communities with mean estimate of children in normal nutrition category of over 61% have statistically insignificant negative association with the risk of infant and child death. The study data reject the hypothesized association between risk of infant and child death with the type of medical care provided to the sick children in the community. The multivariate analysis results established that where malaria is endemic and where breastfeeding durations are 15 months or shorter, infant and child mortality rates are statistically significantly higher (at 99% confidence level) even after controlling for the other factors. Infant and child mortality risks in malaria non endemic communities are 37% lower relative to malaria endemic communities. Children in communities with mean breastfeeding durations of over 15 months have mortality risks about 69% lower relative to those in communities with 15 months and under. The study data also established that the nutrition factor has insignificant impact once other factors are controlled for.

The study has also important findings on the impact of other factors included in the analysis as control variables. For instance, at the current levels of infant and child mortality in rural Kenya, maternal education of under 9 years has insignificant protective effect on infant and child mortality; polygamous marriage unions have significant negative impact; proximate factors such as non prime reproductive maternal ages at child's birth, first and six plus parities, multiple births and preceding birth intervals of under 24 months have higher levels of infant and child mortality.

The findings of this study have a number of implications for policy and for further research. The study shows that there is need to re-orient housing policy in rural areas towards improving household dwelling units; need to intensify malaria control, prevention and treatment programmes; and need to intensify breastfeeding promotion, population information education and communication, and family planning programmes in rural Kenya. The results of the study call for further research to establish the mechanism through which malaria and breastfeeding factors act to affect significantly infant and child mortality; and the mechanism through which polygamous marriage unions act to affect adversely the risk of infant and child death in rural Kenya. The results of this analysis also show the need for sharpening future survey instruments to improve the quality of information to be gathered on morbidity of children, occupation of parents, and other wealth related factors at both household and community levels to enhance analysis of infant and child mortality.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This study investigates the impact of environmental factors on infant and child mortality in rural Kenya. The term environment is used broadly in this study to include physical conditions that affect the child in the household and in the community and for that matter considers factors such as sanitation, water quality, crowding and dwelling unit conditions at the household level; infection loads due to diseases like malaria parasites in the community and the treatment provided to sick children; and protection levels of children in the community arising from factors such as immunization, nutrition, and breastfeeding.

Vital registration statistics on causes of death for infants and children in Kenya for the most recent period although not of very good quality indicate that environmental factors could be contributing substantially since about two thirds of the deaths are attributed to infectious and parasitic diseases [United Nations, 1986 p. 55]. In addition, the contribution of infant and child mortality to the overall mortality in Kenya is very substantial arising from the relatively large numbers of children due to the high total fertility rate estimated at 7.1 for the rural Kenya's population in 1989 [KDHS, 1989: p.22]. The determination of the impact of environmental factors would therefore enhance the understanding of the problem and could provide useful information for improving the survival of the children.

In the attempt to answer the study research question on whether or not environmental factors affect infant and child mortality in rural Kenya, this thesis is organized into six chapters. The remainder of this chapter presents the study problem, the study objectives, the relevant literature reviewed and the study hypotheses. The conceptualization of the study is covered in Chapter 2 and focuses on the theoretical basis, the conceptual and analytical models, and the definitions of the variables included in the study analytical model. Chapter 3 highlights the sources and quality of the study data and the description of the methods of data analysis stating the justification of the methods choice, assumptions and the computation procedures. In Chapter 4, the results of the univariate analysis are discussed. The results of the multivariate analysis focusing on the impact of the environmental variables are presented and discussed in Chapter 5. In Chapter 6, the summary, conclusions and implications of the study are discussed. The references and the appendices are provided at the end of the thesis.

1.2 THE STUDY PROBLEM AND OBJECTIVES

1.2.1 The Study Problem

In Kenya, recent studies have identified factors that are strongly associated with infant and child mortality. These studies have also shown that there exist wide regional and socio-economic-demographic differentials in levels of infant and child mortality [For instance, Anker and Knowles, 1977; Kibet, 1981; Mott, 1982; Mosley, 1983; United

Nations, 1986]. These studies and other relevant studies have been reviewed and discussed in detail in section 1.3 below. Evidence from the most recent data set (KDHS, 1989) indicate that these differentials still persist. On the other hand, studies focusing on the major causes of death among infants and children based on existing data indicates that about two thirds of all these deaths are due to respiratory diseases (mainly pneumonia), diarrheal infections, measles, and malnutrition-malarial associated causes (United Nations, 1986). However, little is known about how these factors found to be associated with infant and child mortality in Kenya work together to influence the mortality rates. In addition, the effects of the environmental factors on infant and child mortality have not been established although the knowledge from epidemiology indicates that the major causes of these deaths are attributable to environmental contamination, heavy loads of parasitic infections and not readily available health care services for early treatment and prevention.

This study focuses on the impact of environmental factors at the household and at the community levels on the risk of death for the rural children aged under five years. It is viewed to be of both policy and research relevance. Each year, a large number of infants and children are at risk of death in Kenya arising from the persistent high fertility rate estimated at a total fertility rate of 6.7 for the entire country and 7.1 for the rural population in 1989 (KDHS, 1989: table 3.5, p. 22). From the policy point of view, the findings of this study are expected to provide required information to formulate appropriate policies and short-term intervention programmes aimed at reducing mortality.

According to child survival hypothesis advocates (e.g Preston, 1978) significant reduction of infant and child mortality may also result in further reduction in fertility. From the academic point of view, the findings of this study are expected to contribute towards a better understanding of the mechanism through which some of the factors already identified to associate strongly with child mortality operate to affect child mortality and in particular the role of environmental factors in the operations, if any.

1.2.2 Objectives of the study

The broad objective of this study was to examine the effects of the household and community environmental factors on infant and child mortality in Kenya. The specific questions that were to be answered by this study were:-

(i) Do the household and community environmental factors have significant effects on risk of death for children aged under five in rural Kenya?

(ii) Do the significance and impact of the socio-economic and other proximate determinants of infant and child mortality change when the environmental factors are brought into play?

1.3 LITERATURE REVIEW

The review of the relevant literature on determinants and correlates of infant and

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1.3 LITERATURE REVIEW

The review of the relevant literature on determinants and correlates of infant and the child on the basis of the social and economic characteristics of the parents (e.g educational attainment and occupation). In general, the household environmental and the socio-economic characteristics of the parents are also viewed to reflect the general standard of living in the household. On the other hand, the community environmental factors reviewed were those factors that relate more closely to epidemiological principles that explain the causes and spread of diseases in communities although these too relate to a lesser extent to the socio-economic differences. In this respect, studies that focused on the effects of levels of infections in the community environment, of the protection against prevalent diseases in the community, and of the type of medical care provided to sick children in the community that also affect the risk of child death were reviewed under community level environmental or contextual factors.

In order to highlight only the important factors that relate to the study under each of the four topics, the strategy adopted was to review the general evidence then examine evidence specific to Kenya regarding the significant determinant factors or distinct patterns of relationships with infant and child mortality.

1.3.1 Household level environmental proximate determinants

The importance of water supply and sanitation as determinants of infant and child mortality have been underscored by several studies from other developing countries. Merrick (1985) studied the effect of piped water on early childhood mortality in urban

Brazil and concluded that the differentials by income class declined significantly with increased access to piped water. Puffer and Serrano's (1973) study had also earlier identified lack of adequate water sources as one of the important household factors associated with high infant deaths in Latin American cities. Meegama (1980) concluded that public health measures such as improved sanitation were important household factors associated with child mortality in Sri Lanka. Martin et al. (1983) investigated further how education and sanitation operate simultaneously with other socio-economic-demographic household factors to affect child mortality in the Philippines and concluded that the effects of education were reduced when the type of sanitary facility including water source were added in the analysis.

In most underdeveloped settings, children share the environmental household hazards including limited and contaminated water supplies, inadequate feces disposal facilities and unhygienic home conditions a fact ascertainable through the analysis of major causes of morbidity and mortality. The Kenya Demographic and Health Survey data which contain information on morbidity among the under five years old in 1989, provide only some indication of the morbidity rates in Kenya since the data collected were restricted to illnesses as reported by the mothers and covering only the limited two week period prior to the survey date. Such data suffer from some inherent biases, for example towards dry season illnesses since most of the interviews were reported to have been conducted during the dry season. Nevertheless, the data indicate that diarrhea was the second most common illness among the children (13 percent of the children were reported to have suffered from it) and was most prevalent among those in the age group 6 to 17 months which also corresponds to age at weaning of children. Diarrhea was rated the second major cause of death among children under five years of age in Kenya during the late 1970's, with pneumonia topping the list of major causes of the deaths (United Nations, 1986). Further analysis of the 1977 causes of death data attributed 16 per cent of all the deaths of children aged under five years in Kenya to diarrhea, though diarrhea was found to be the top cause of death in Coast Province and the Lake Victoria region whose rate was estimated at six times higher than in Central Province (United Nations, 1986).

Studies focusing on the bacterial content of food and water have illustrated that levels of weaning food contamination in developing countries are unacceptably high due to conditions under which they are prepared and stored (Butz et al., 1982). In Kenya, available evidence shows that children receive supplements generally through use of bottles since the practice of day time breastfeeding is declining especially for mothers working in formal employment and also during heavy work peaks (weeding and harvesting seasons) in the rural areas [Van Steenbergen et al., 1981]. A case study relating diarrhea incidence to weaning foods and water done in Machakos District in Kenya demonstrated that over half of the weaning food samples taken showed severe contamination with diarrhea-causing bacteria (E. Coli, Shigella, and Salmonella) which was a much higher contamination percentage when compared with water samples drawn from rivers and open wells. The authors arrived at the conclusion that contaminated weaning food was the probable major cause of diarrhea in Machakos (Van Steenbergen et al., 1978). The Machakos study is one of the studies that underscores the importance of adequate feces disposal facilities and the hygienic home conditions affecting safe preparation, handling and storage of weaning foods which has also association with diarrheal mortality among infants and children in Kenya. The micro level analysis of determinants of infant and child mortality in Kenya conducted by Anker and Knowles (1977: p.24) also established that use of pit toilets was a statistically significant protective factor and that quality of water and dwelling were strongly associated but not statistically significant determinants. However, it can reasonably be argued that availability of clean water reduces the load of infections by diluting and washing away the infectious agents. Similarly, adequate sanitation facilities helps on removal of the infectious agents in the environment.

Crowding as a household environmental factor has been found to be important in the spread of infectious diseases as recently been highlighted by the work in Guinea Bissau where Aaby (1987) found that the case fatality rates of measles were significantly higher among secondary cases who had contacted the measles inside the households. Aaby concluded that crowding within the household resulted in intensive exposure and larger dose of infective virus which in turn was the major determinant of measles severity and mortality. There is also a strong likelihood that crowding within households may constitute a risk factor in diarrheal and in some respiratory disease mortality since all the bacterial and viral agents of these diseases can be transmitted by person to person contact. Transmission of diseases such as influenza, which falls under the above mentioned categories, can occur when sleeping arrangements of children are poor such as in congested ill ventilated dwellings. No studies are readily available that relate to the effect of crowding on child mortality in Kenya and in other developing countries.

1.3.2 Maternal, nutrient deficiency and injury factors

The maternal proximate determinants of infant and child mortality are those mainly referred to as biological factors and at times referred to as demographic factors especially by the epidemiologists. The maternal proximate factors include maternal age at birth of the child, birth order, birth intervals and type of birth (single/multiple). In addition to the maternal factors, there are other proximate factors such as nutrition that may determine the outcome of attack from infectious and parasitic diseases and also the physical injury that expose the individual child to the risk of death.

The importance of sex as a factor influencing early life mortality is amplified by the infant and child mortality rates for 40 countries with more complete and reliable data where mortality was lower for females in the first year of life in all except one (United Nations, 1978). The WHO investigation also showed that higher mortality risk for the male sex was evident for almost all causes of death (WHO, 1978). These differences have been attributed mainly to inherent biological differences and to the value attached to children in various cultures which in turn could affect family's investment in child care in light of the expected returns. For instance, marriage expectations can be a major economic factor in child survival rates in South Asia region where female dowry is a main concern and thus is characterized by higher survival rates for males (Poffernberger, 1991). Mott (1982) argued that the slightly higher child survival rates for the females than for the males in Kenya could be attributed partly to the high value attached to girls for the brideprice they bring. In developing countries in general, Rutstein found using World Fertility Survey data that 27 out of 29 countries had excess male infant mortality, and that the male disadvantage ceased to be apparent for the toddlers and older children under age five years (Rutstein, 1983: p. 23).

Data from Kenya suggest that sex differentials in infancy and childhood are small (for instance, infant mortality rate using 1979 census was 89 for males and 81 for females) compared with those found in other populations and that the differences are largely due to inherent biological differences between the sexes rather than to cultural practices which are thought to lead to differential child care for sons and daughters (United Nations, 1986: p.45). However, the only exception to this rule is in Turkana District which had reported excess mortality among the females. The examination of the data from the nutrition surveys undertaken in Kenya from mid 1970's also show that there are no significant differences in nutritional status between boys and girls. The most recent data set also confirms that sex differentials in infant and child mortality are still small (KDHS, 1989). A multivariate analysis of determinants of infant mortality in Kenya done by Mott (1982) found that males were significantly less likely to survive the first year. Anker and Knowles (1977) also found that males had significantly less survival chances from birth to age three years.

Studies focusing on infant and child mortality differentials by age of mother at child bearing have upheld a general U-shaped pattern except in situations of very high mortality levels [Arriaga, 1980; Rutstein, 1983; Bongaarts, 1987]. The pattern is such that children born to mothers in prime reproductive ages (20-34 years) have the lowest mortality while those born to older mothers (35+ years) and to relatively very younger mothers (under 20 years) have relatively higher mortality. The pattern in Kenya is not clear but shows evidence of the lowest mortality among the births to women in the prime years of 25-34 [Mott, 1982]. Further analysis of the same data (used by Mott) was later done by the United Nations Population Division (unpublished) and indicated that maternal age and birth order were correlated and explained that the observed lower mortality for the birth orders two to four could be attributed to the relatively very high infant deaths suffered by first born children to mothers under 20 years.

The pattern of infant and child mortality by parity whereby first and higher (4+) birth orders have relatively higher mortality risk have been upheld and explained by a number of recent past researches [Omran, 1974; Mott, 1982; Pebley and Stupp, 1987]. Rutstein analysis of this relationship using data from 29 developing countries concluded that the relationship between mortality and birth order was far from uniform and that the observed excess mortality of the higher order children in countries with moderate levels of mortality could be attributed to joint effects of low socio-economic status and unrestricted fertility (Rutstein,1983: pp. 29-30). The possible explanations are that first born children are likely to be born to mothers who are biologically, mentally, socially and economically unprepared to bear and bring up a child. On the other hand, children of higher parities are likely to be born to mothers who are physically worn out and older but with also a possibility of obtaining additional care from older siblings hence rendering the relationship ambiguous. Lack of clear pattern of the relationship between infant and child mortality and parity in Kenya was noted by Anker and Knowles (1977: p. 21) when they stated that there was inconclusive evidence regarding the effect of parity on survival rates up to age three years.

Although shorter intervals between births have been associated significantly with increased risks of infant and child mortality, there have been discussions on whether the effect of short birth interval is not being confounded by a number of factors including the following:- short gestation resulting into premature births associated with high mortality [Miller et al., 1992]; breastfeeding periods and patterns [Palloni and Tienda, 1986; Trussell and Pebley, 1984]; prior child mortality [Hobcraft et al., 1985]; poor parenting skills [Das Gupta, 1990]; and low socio-economic status [Winikoff, 1983]. The pattern of shorter birth intervals being associated with higher child mortality was also found apparent by Rutstein (1983) when he used data from 29 developing countries and found that children born after short birth intervals were much more likely to perish in all ages below five years than children born after normal length of time in almost all the countries analysed. Results of the analysis of both the Kenya Fertility Survey and the Kenya Demographic and Health Survey show that previous birth intervals of less than two years are associated with higher risk of infant and child mortality (KDHS, 1989: table 6.3, p. 59). The data also show that infant and child mortality rates decline slightly from birth interval of 24-36 months to interval of 48 months and over. These differences in the Kenya Fertility Survey data were found to persist even after adjusting for other factors such as parents' occupation, mother's education and religion (United Nations, 1986: p. 54).

Multiple births such as twins and triplets have been found to have much smaller chances of surviving especially during infancy when they are compared to single births [WHO, 1978; and Rutstein, 1983]. The WHO study in 1978 attributed the excess mortality risk for the multiple births to low birth weights and below normal gestation periods. The other argument advanced is that greater competition among children for scarce household resources needed for food, clothing and care may result in smaller share for each of the multiple child [Trussell and Pebley, 1984]. No firm conclusions have been drawn from existing very limited studies (due to the fact that it is a rare event as depicted by the estimate of 2 per cent of all the births in the 1989 KDHS data set used in this study, and just under 2 per cent of all the births in the 29 developing countries whose data were analysed by Rutstein in 1983). Rutstein found that on the average children of multiple births had more than four times the chance of dying during infancy when compared to single births.

1.3.3 Socio-economic factors

As was indicated earlier, the factors reviewed under this category were those that determine infant and child mortality by affecting the individual knowledge, skills and social attitudes of the parents on the provision of child care and also those that affect the general economic circumstances of the household. Given the synergistic nature of the relationships among these factors, it is not practically possible to isolate the independent effects of each of them and so the reviewed literature on some of the factors discussed below should be seen within that perspective.

A number of researches using data from African countries have established that educational attainment of parents is inversely related to infant and child mortality (Caldwell, 1979 and 1981; Cochrane, 1980; Farah and Preston, 1982; Anker and Knowles, 1977; Kibet, 1981; Mott,1982; and Mosley, 1983). The inverse association has been attributed to many causes including breakdown of unfavourable traditional child raising practices, increased hygienic practices and use of modern medical facilities, better nutrition knowledge and child feeding practices, and increased amount of income plus redistribution of family resources in favour of children. Researches from other developing countries on determinants of infant and child mortality have also underscored the importance of the education factor. Behm (1979) found that in Latin America, the effects of rural-urban residence on child mortality declined sharply when differences in mother's eduction were controlled for. Palloni (1981) underscored the importance of social circumstances in which the mother lives, and concluded that in poorer settings the uneducated mothers were at far greater disadvantage with respect to the survival chances of their children compared to the more educated. Merrick (1985) and Puffer and Serrano (1973) had also shown that education was an important determinant of infant and child mortality in Latin American countries. The studies by Trussell and Hammerslough (1983) using Sri Lankan data and by Martin et al. (1983) using Philippines data confirmed the importance of the education factor in childhood mortality in Asian countries.

In Kenya, it is still not clear how much of the relationship between education and child mortality is due to other factors correlated with education and how much is due to direct effects of education. In addition, review of researches on the education factor as one of the determinants of child mortality in Kenya contained in the United Nations (1986) publication indicated that the education variable was a central social determinant but its impact could not be isolated completely (United Nations, 1986: p. 51). The 1986 United Nations study found that the effects of maternal and paternal education remained significant when other related variables such as father's occupation, mother's work status, religion and ethnic group were controlled for. Anker and Knowles (1977: p. 23) found that mother's educational attainment was still significant when household income was introduced in the analysis and that the education variable also captured some effect due to income variable. Mosley (1983) used data at provincial administration unit level and argued that the geographical differences in child mortality could be explained by education and nutrition which were in turn a result of differences in levels of economic and social development.

The other socio-economic factors that are likely to influence the general economic circumstances of the household are the father's occupation, mother's work status and assets. Due to difficulties in gathering accurate data on occupation in developing countries, not many comparative investigations have been conducted on the effects of occupation on infant and child mortality apart from the few studies such as the one done by Hobcraft et al. (1984) using World Fertility Survey data from 10 developing countries including Kenya.

Analysis of child mortality rates by father's occupation using data from the Kenya Fertility Survey indicated that those with the highest mortality risk were the children of agricultural workers who worked mainly at home and that their reported child mortality rate was about 57 per cent higher than for the professional cadre of workers even after controlling for maternal differences (United Nations, 1986: p. 50). The study also found that there was insignificant difference between child mortality rates between professional and clerical cadre occupational categories as well as insignificant difference among the other remaining occupational groups. Although there is a possibility that father's occupation could reflect income differentials, its possible associations with socio-economic and cultural factors complicate the determination of its independent effect on child mortality. The effect of mother's employment outside home on child mortality has not been studied in Kenya but there is a possibility that this variable could affect child survival through differences it may cause in income, child feeding practices and in use of medical care [Popkin, 1975 and Kumar, 1977].

Since cultural and religious factors are usually unique to a region, no comparative studies of their effects on child mortality across regions and countries have been undertaken although child mortality differentials by these factors have also been noted in Asia (Meegama, 1980; Trussell and Hammerslough, 1983) and in Africa (Caldwell, 1979; Anker and Knowles, 1977; Kibet, 1981; and Mott, 1982). In most traditional societies, the mother has full responsibility for child care but she may have little control over allocation of resources to herself or her child or even to critical child care practices [Safilios-Rothschild, 1980]. One key change in traditional societies produced by mother's education is the shift of household power relationships towards the mother to the benefit of her offsprings [Caldwell, 1979].

In Kenya, type of marital union, which relates closely to cultural and religious factors, has also been found to have some effect on infant and child mortality [Anker and Knowles, 1977; Kibet, 1981; and Mott, 1982]. Polygyny though declining in Kenya (from 30 per cent in 1977/78 estimated using Kenya Fertility data to 23 percent in 1989 estimated using 1989 Kenya Demographic and Health Survey data) is less common in urban areas and relates to cultural, religious and income differences. Although women's current marital status may be different from her status at the time of births of some of her older children (arising mainly from widowhood and remarriages), polygamous women reported a child mortality rate between 10 to 15 percent above that for monogamous women even after controlling for other factors such as religion, mother's current age and ethnicity (United Nations, 1986: 50). Mott (1982) also found that polygamy was a statistically significant determinant of infant mortality in Kenya. In addition, ethnicity and religious affiliations have been found to depict differentials in child mortality. For instance, moslems have a higher child mortality rate compared to the christians; the Nilotic tribes have a higher child mortality rate compared to the Central Bantus; and also these differences are removed when other regional variables that measure differences in socio-economic status are introduced in the analysis (United Nations, 1986).

1.3.4 Contextual factors

Studies focusing on the contextual factors relating closely to the prevalence, transmission, immunization and treatment of common diseases in a geographical area that affect directly or indirectly child mortality rates reviewed in this section should be seen to be only loosely divorced from the socio-economic factors as was earlier noted. Society's beliefs about disease causation shape behaviour that may have impact on the proximate determinants of child survival ranging from ritualistic disease prevention practices to choice of therapies and also from practitioners for sickness care to sexual taboos and abstinence to prevent illness in the suckling child [Fabrege, 1972; Kielman et al., 1975]. In this sub-section therefore, the review that follows focuses on only those factors that relate to child mortality that arise partially from high infection loads in the climatic environment (for instance, malaria prevalence), from level of protection against killer diseases in the community (particularly, protection attained through breastfeeding, immunization and nutrition factors), and from methods commonly employed in the community to treat child illnesses (use of modern and traditional medical technologies).

There are studies that have argued that malaria control has significant reduction effect on infant mortality. Farinaud and Choumara (1950) attributed 40 percent of the mortality decline in the Indochinese Plateau to malarial control. In Sri Lanka, the difference on the estimates of the contribution of malaria control programme to mortality decline during the post world war II period by Newman (1969) and Gray (1974) were due to the differences in the methods used. Newman (1969) used a model with the absolute change in crude death rates as the dependent variable and estimated the malaria impact at 42 percent while Gray (1974) used a model with the proportional change in the crude death rates as the dependent variable and estimated the malaria impact at 23 percent. Molineaux and Grammicia (1980) reported that in the Garki District in Northern Nigeria infant mortality rate declined from 245 per thousand live births before malaria intervention project to 55 in the intervention year.

On the other hand, there are a few studies done in other African countries that have advanced the argument that the difference between mortality in malarial and non-malarial zones are relatively small due to malaria immunity among children in malarial zones [for instance the study by Garnham (1935) using data from Kenya; the Blacklock and Gordon (1925) study using data from Siera Leone; and the recent study by McGregory et al. (1983) using data from the Gambia]. Despite the lack of complete agreement on the impact of malaria on infant and child mortality, scientific evidence has established the following about malaria:- that malaria can give rise to high fever and anemia and also obstruct the blood vessels of the brain resulting in coma and death; that malaria parasites can contribute to complex malnutrition and infection that increases the risk of child death; and that chronic malaria illness in pregnant mothers retards intra-uterine growth of the foetus and may result in low birth weights in the new born infants which indirectly increases the risk of neonatal mortality. The pattern of malaria transmission varies from high (in endemic areas) to low (in non-endemic areas). In Kenya, the areas in the Coastal Belt and in the Lake Victoria Basin are malaria endemic and are also high child mortality areas. Recent studies by Anker and Knowles (1977) and by Kibet (1981) found that malaria had a significant negative effect on child survival rates.

Large scale studies linking nutritional status and child mortality though few in number have indicated that anthropometric indicators are significant predictors of infant and child mortality risks (Sommer and Loewenstein, 1975; Kielmann and McCord, 1978; Chen et al., 1980; Trowbridge and Sommer, 1981). The general pattern established is that mortality risk with respect to malnutrition is curvilinear such that severely nourished children have many times greater risk and moderate nourished children have somewhat higher risk when compared to well nourished children. There is also a general agreement from available literature that the malnutrition problem in developing countries is mainly associated with poor diets and infectious diseases. Some cultural practices that restrict some foods in the diet especially during child infections may deny the child essential nutrients. Other researchers have argued that infectious diseases such as diarrhea affect nutrient absorption and utilization and hence play a major role in vicious circle of infection and malnutrition problem (Mata et al., 1977). Although the mechanism linking malnutrition and mortality is still debatable in biomedical sciences, it appears reasonable to argue that severe malnutrition impairs the immunocompetence in children. In simple terms, severe nutrient deficiency reduces the usual antibody response abilities of the body cells to fight against infections.

In Kenya, the second and third national nutrition surveys conducted in 1978 and 1982 respectively showed that the malnutrition problem was most prevalent in Coast Province and was also almost as serious in Nyanza and Eastern provinces. The malnutrition problem especially in Coast Province was attributed to poor feeding patterns (for instance, baby food lacked essential elements such as milk and sugar). Although areas with more malnutrition were found to have also higher child mortality rates, the regression analysis using district level proportion of children categorized nutritionally as stunted yielded results indicating insignificance of the nutrition factor as a determinant of child mortality (United Nations, 1986: p. 61). However, this lack of significance was attributed by the United Nations 1986 study to the use of proportion stunted which is considered to be an inferior measure of malnutrition when compared to use of proportion categorized as normal which could not be computed from data available to that particular study then.

Available evidence mainly from case study projects undertaken in developing countries show that a considerable proportion of deaths of children are attributable to immunizable diseases such as tetanus, measles and pertussis [Voorhoeve et al., 1978; Chen et al., 1980; Handayani et al., 1983; and Hull et al., 1983]. Chen et al. (1980: p.27) estimated the percentage of children whose deaths were attributed to four diseases (tetanus, pertussis, measles, and lower tract infection) at 35 percent using data from the Matlab Thana case study in Bangladesh. Similar percentage estimates were obtained by Handayani et al. (1983: p.91) using Javanese village data in Indonesia. The measles infected Gambia villages were followed longitudinally over a nine-month period and found that the relative risk of mortality for a child with measles was 13.7:1 [Hull et al., 1983: p.973]. In the Machakos project in Kenya, a rural population of 24,000 were followed prospectively for three years and pertussis was found to account for 4.1 percent of all deaths in the 0-15 years age group [Voorhoeve et al., 1978: p.135]. Lack of commitment in three main areas contributes to failure of attaining high immunization coverage and use of existing technology for protection against these diseases [Foster, 1984]. These are lack of proper allocation of priority and resources by governments for prevention programmes especially for the rural poor; inadequate health services for promotion of public awareness, provision of immunization and basic curative services; and also lack of commitment on the part of the public to participate and be responsible for their own health care.

In Kenya, the exact proportion of deaths attributable to measles though difficult to determine due to its interaction with other major causes of child deaths such as pneumonia and gastroenteritis, was estimated to be associated with about 20 percent of deaths for the under fives in 1970's (United Nations, 1986). The immunization of children against these diseases in Kenya is being done under the programme locally known as Kenya Expanded Immunization Programme (KEPI) implemented by the Ministry of Health with assistance from international donor organizations such as the United Nations Children's Fund and the World Health Organization.

Several studies have noted a lower rate of mortality or a lower proportion of dead among breastfed infants [Puffer and Serrano, 1973; Woodbury, 1922; Janowitz et al., 1981; and Lapage et al., 1981]. The protective role of full breastfeeding was illustrated by the Butz et al. (1982) study that found using Malaysian data that an additional week of full breastfeeding in the first one month of life related to a decrease in mortality of 16 deaths per thousand for those aged under six months and a decrease of 1.8 deaths per thousand for those in the ages 6 to 12 months. Another interesting study in a rural setting in Chile by Plank and Milanesi (1973) related the effect of breastfeeding with infant mortality taking into account the improvements in the socio-economic status suggested that full breastfeeding during age one month provided protection against negative effect of early weaning while partial breastfeeding did not.

From the existing literature, breastfeeding has been shown to have an indirect effect on child mortality through its three roles. First, breastmilk provides a major nutrient source in a child's diet especially where other types of weaning food supplements given to the child contain inadequate nutrients. Secondly, breastfeeding extends the postpartum anovulatory period and hence lengthens intervals between births especially in communities with high intensive breastfeeding. Longer birth intervals as was earlier discussed in detail are associated with lower risk of child mortality. Thirdly, breastmilk is an important contributor to the child's immunologic defence system especially in environments where the load of infection is high and the health care services for early treatment are not readily available and hence is an important factor for improvement of child survival chances particularly during the first six months. Due to the interaction between breastfeeding and other socio-economic variables, the direct assessment of its reduction effect on infant and child mortality is difficult especially in Kenya.

However, Eelen (1983) studied the impact of breastfeeding on infant and child mortality with varying incidence of malaria in Kenya and concluded that reduction of duration of both full and partial breastfeeding increases childhood risk of death and that the impact was greater in high malarial zones. From the most recent data in Kenya, there is evidence to suggest that an inverse relationship exist between modernization factors (such as education and urbanization) and the mean duration of breastfeeding and that some areas such as Coast Province which experience high child mortality also have relatively shorter mean durations of breastfeeding (KDHS, 1989: pp. 16-17).

From the available literature on rapid mortality decline in developing countries since the second world war, there is much evidence in support of the advancement and use of modern medical technology as a major determinant of infant and child mortality [For instance, Stolnitz, 1954; Davis, 1956; and Arriaga and Davis, 1969]. It is therefore the expected that availability and utilization of modern health technology in the community in event of illness has some association with the level of infant and child mortality although results of some studies that used data from Kenya do not to readily confirm this expectation.

Availability of health services measured by the number of hospital and dispensary beds per capita at district level was found not to be a significant determinant of infant mortality rate in Kenya between 1969 and 1979 (United Nations, 1986: p. 53) and the type of medical care defined as use or non-use of hospitals or traditional medicine was also found to have no statistically significant effect on infant and child survival rates in a combined sample of rural and urban Kenya (Anker and Knowles, 1977: p. 24). However, in rural Kenya use of traditional medical care was found to have a statistically significant negative effect on infant and child survival rates (Anker and Knowles, 1977: p. 25).

1.4 THE STUDY HYPOTHESES

The broad hypothesis of this study was that household and community environmental factors have significant effects on infant and child mortality in rural Kenya. The following were the three specific hypotheses derived from this broad hypothesis and based on the reviewed literature in the previous section:-

(i) that at the household level, quality of water, quality of sanitation, quality of housing and crowding in the household by siblings aged under 5 years are significant proximate environmental determinants of child survival. Hence, the probability of child survival is expected to be higher for children in households with clean water, hygienic sanitary facilities, better quality housing and with less sibling crowding.

(ii) that at the community level, the load of parasitic disease infections, nutritional status of children, levels of children's immunization coverage, mean durations of breastfeeding and type of medical care commonly provided in event of children's illnesses are significant environmental contextual factors of child survival in addition to the socio-economic factors. Hence, the probability of survival is expected to be higher in community environments with relatively less load of parasitic infectious diseases, with higher proportion of children fully immunized, with higher proportion of children well nourished, with relatively longer mean durations of breastfeeding and with higher proportion of children provided with appropriate medical care in event of illness.

(iii) that the household and community environmental factors have some effects on the impact of other factors that also determine the risk of infant and child death.

Details of the theoretical basis, the analytical model, the data set, the specification of the variables, and the methods chosen for testing these study hypotheses are presented in the subsequent two chapters.

CHAPTER 2

CONCEPTUALIZATION OF THE STUDY

2.1 INTRODUCTION

Four view points have been advanced in the attempt by researchers to explain the substantial mortality decline in the 18-19th century Western Europe and in the developing countries in the post world war II period. These view points are discussed in detail by McKeown (1976) in his book entitled "The Modern Rise of Population". The common ground for these four view points is that the decline in mortality was due essentially to the reduction of deaths from infectious diseases and probable decrease from two non infectious causes namely infanticide and starvation. The basic difference in these view points is with respect to the explanations of the reduction of infectious diseases. However, the efforts towards providing explanation to the mortality phenomenon dates back as early as 1798 when Malthus formulated a mortality theory with two propositions that the level of mortality is determined by availability of food and that the numbers born are greater than can survive [Malthus, 1798].

In section 2.2, reasons provided for reduction of infectious diseases and thus mortality decline by each of these four view points are discussed. The integration of these view points in the study is discussed in section 2.3. The conceptual framework and the empirical model used in the study are also discussed in section 2.4. In the final section of this chapter, the variables included in the empirical model used in testing of the study hypotheses are defined.

2.2 VIEW POINTS ADVANCED ON MORTALITY DECLINE

2.2.1 Change in character of infectious diseases due to evolution balance

According to the advocates of this view point (e.g Magill, 1955; Dahlberg, 1955 and Andrewes, 1965) who were mainly Immunologists, the equilibrium between the micro-organisms that cause infections and the host (man) was disturbed during the first agricultural revolution. The domestication of animals and growing of crops by man increased the rate of infectious diseases. The second agricultural and industrial revolution in the 18th century initiated the change towards attainment of the balanced evolution between man and the micro-organisms that cause infection. The basis of this thinking stems mainly from the speculations regarding the disappearance of plague and reduction of some air-borne diseases morbidity such as scarlet fever and influenza in Western Europe.

The explanations provided by the advocates of this school of thought are that parasites and hosts have evolved in the balance and that the relationship between them is constantly changing; that it is only in special circumstances that the micro-organisms cause disease; and that animals including man are protected to a lesser extent by acquired immunity. Since this view point do not adequately explain the decline in water-borne and vector-borne parasitic diseases, it cannot be used to explain the substantial decline in the infectious diseases especially in the developing countries.

2.2.2 Medical advances

A number of researches support the view that the decline of mortality in the 18-19th century Western Europe was mainly brought about by medical advances (Griffith, 1925; Razzell, 1965). Stolnitz (1954) also ascribed the rapid mortality decline in developing countries in the recent decades to importation of advanced medical technology and cites the case of Sri Lanka where malaria was eradicated by use of imported insecticides.

The medical advances include expansion of hospitals, dispensaries, and midwifery services; improvements in medical education; advances in understanding of human physiology and anatomy; and introduction of curative medicine and protective measures (such as immunization vaccines). Griffith (1925 and 1967) explained the decline in mortality rate in England in terms of changes brought about by medical advances in medical practices, availability of hospitals and dispensaries, and midwifery services. Ruzzell (1965) argued that inoculation against small pox was responsible for the major reduction in mortality. On the other hand, some researches dispute the explanation that the mortality decline in the 18-19th century Western Europe was due mainly to advancement in immunization and curative medicine (McKeown and Brown, 1955; and

McKeown et al., 1975).

McKeown and Brown (1955) examined medical evidence related to English population changes in the 18th century and concluded that the mortality decline was due to general advancement in the standard of living in consequence of economic development of that period. They argued that the contribution of hospitals, physicians including midwifery had questionable effect on infant and maternal mortality due to increased chances of secondary infections resulting from unhygienic non septic environmental conditions in the hospitals and dispensaries at that time. This argument was also supported by earlier studies done by Ericksen (1874) and Simpson (1855).

2.2.3 Improvements in domestic, working and general environmental conditions

The advocates of this school of thought (e.g McKeown et al., 1972; and Beaver, 1973) argue that the decline of mortality in the 18-19th century Western Europe was mainly due to reduction of exposure to infection arising from control of domestic, working and general environment. This view also relates mortality decline with improvements in the levels socio-economic development and has been used to explain the mortality decline in developing countries (e.g Arriaga and Davis, 1969).

The basic argument is that improvements in the environment through personal and public hygiene measures reduce substantially the water-borne diseases. The public health measures include improved quality of water supply and efficient sewage disposal; improved ventilation and prevention of crowding; and isolation of those suffering from communicable infectious diseases. The personal hygienic measures include mainly cleanliness through bathing; washing clothes, utensils and hands.

McKeown et al. (1972) examined the 18-19th century data on causes of death from Sweden, France and Ireland and concluded that the decline in mortality was mainly due to improvements in the living conditions in the area of public health measures such as purification of water supply and efficient sewage disposal. Beaver (1973) attributed the reduction in infant and child mortality to control of gastro-enteritis in cow milk through pasteurization. Arriaga and Davis (1969) using life tables for Latin American countries covering the 1860's to 1960's period concluded that public health measures exercised a strong influence on mortality independently of economic development. They also argued that prior to the 1930's mortality decline was slow but was mainly influenced by economic development. They also generalized that the rapid mortality decline in the developing countries in the recent decade had been accelerated by the importation of public health techniques, personnel, and funds from industrialized countries regardless of local economic development or non development [Arriaga and Davis, 1969: p.234].

Critics of this school of thought argue that improper purification of water and inefficient disposal of sewage can lead to higher mortality. Chapman (1972) cites the case of the Great Stink and high mortality in the city of London. This thinking also does not provide adequate explanation of the decline of air-borne infectious diseases.

2.2.4 Improvements in nutrition due to greater food supplies

This view point is consistent with the Malthusian mortality theory which linked food supply and mortality [Malthus, 1798]. The Malthusian argument is that food supply and population stayed in balance such that when food supply rose above subsistence level then mortality fell and vice versa. This view point is also close to the "Climatic" theory of mortality advanced by Utterstrom (1955). Utterstrom using Scandinavian data argued that it was climate and not economic change that was responsible for mortality decline. The worsening climate leads to increased mortality and vice versa.

According to Langer (1975) and Behar (1974), the improvement in nutrition due to greater food supplies was responsible for a substantial and prolonged decline in mortality in 18-19th century Western Europe. Mckeown (1976) also supports very strongly this view point. The increase in food resulted from introduction of potato and maize in Europe from America, advancements in agricultural production and food storage, and improvements in distribution of food through improved transportation [Langer, 1975]. Behar (1974) argued that an adequate diet is the most effective vaccine against most of the diarrhoeal, respiratory and other common infections.

In the developing countries, recent experience acquired suggest that malnutrition contributes largely to the high levels of infectious deaths and that populations more prone to malnutrition also suffer more seriously when infected [WHO, 1973]. These recent experiences also indicate that half to three quarters of all the statistically recorded deaths of infants and young children are attributed to a combination of malnutrition and infections [WHO, 1973].

2.3 INTEGRATION OF THE VIEW POINTS IN THIS STUDY

From the discussions in section 2.2, it is apparent that the four view points advanced to explain mortality decline are not completely divorced from each other. However, the enormous mortality reduction cannot be attributed to change in the character of diseases. It is therefore safer to take into consideration the other three view points (on medical advances, environment improvement, and on improvements in nutrition) for better explanations of the past mortality changes and future projections. The need for integrated approach is also apparent from Preston's (1980) study that established that mortality decline cannot be disassociated completely from economic levels of the country and from factors exogenous to the country's economic level. Similar position was suggested by Bourgeois-Pichat (1956) who argued that while public health programmes for control of diseases and progress in environmental sanitation have been extremely successful in bringing about rapid short-term mortality decline in developing countries, other factors such as social and economic might assume greater importance in achieving long-run effects.

Since the objective of this study was to determine the impact of environmental factors on infant and child mortality in Kenya, the other two view points on medical advances and improvement in nutrition need to be controlled for among other factors. The environmental factors considered in this study are mainly of a public health nature focusing on prevention of infectious and parasitic diseases through improvements in sanitation (such as use of hygienic toilet facilities), in water supply and in housing conditions. Within the broader context of community environment, the study also focuses on prevention and control of infectious and parasitic diseases (such as malaria and measles) through use of medical technology such immunization and therapy. The study also focuses on the status of nutrition of children and breastfeeding durations in the communities. In addition, socio-economic and other factors such as maternal factors will be considered in the study.

The conceptual framework developed by Mosley and Chen (1984) for studying child survival in developing countries integrates these views and the other factors that need to control for in this study. This framework was therefore considered most relevant to the study.

2.4 CONCEPTUAL FRAMEWORK AND THE STUDY EMPIRICAL MODEL

As indicated already in the preceding section, the conceptual framework proposed by Mosley and Chen in 1984 for analysis of child survival in developing countries was found to be relevant to this study. The Mosley/Chen framework views child death as a consequence of a set of five behavioural mediated biological mechanism referred to as proximate determinants. These sets of proximate determinants which are defined and discussed in detail in the sub-section that follows consist of maternal, environmental contamination, nutrient deficiency, injury and disease control factors. This proximate determinants framework links the individual child death with the underlying socio-economic factors. The approach incorporates both social and biological variables and is based on the premise that all social and economic determinants of child mortality operate through a common set of biological mechanisms or proximate determinants to exert an impact on mortality.

In order to facilitate the attainment of the objectives of this study, the Mosley/Chen conceptual model was slightly modified to allow for incorporation of community level environmental factors which can also be viewed as contextual factors that do not fit very neatly within the group of socio-economic factors. The first sub-section focuses briefly on the specific premises and operations of the Mosley/Chen framework and its modification to suit the study while the second sub-section focuses on the empirical model used in this study.

2.4.1 Premises and operations of Mosley/Chen conceptual framework and its modification for this study

The Mosley/Chen framework is fully documented elsewhere [Mosley and Chen, 1984]. The discussion that follows under this sub-section has thus been limited to the major points that were considered to require amplification for purposes of this study only. The Mosley/Chen model is based on the following five premises:-

(i) that in an optimal setting, over 97 per cent of newborn infants can be expected to survive through the first five years of life.

(ii) that reduction in the survival probability in any society is due to the operation of social, economic, biological and environmental forces.

(iii) that the socio-economic determinants must operate through one or more basic proximate determinants that in turn influence the risk of disease and the outcome of disease processes.

(iv) that the specific diseases and the nutrient deficiencies observed in a surviving population may be viewed as biological indicators of the operations of the proximate determinants.

(v) that growth faltering and ultimately mortality of children are the cumulative consequences of multiple disease processes.

The last four premises above in the Mosley /Chen model basically spell out the specific mechanism through which reduction of child mortality can be achieved, while the first premise spells out the level of reduction that is possible to attain using the current level of medical knowledge and technology. The five sets are subdivided into fourteen socio-economic proximate determinants in the original Mosley/Chen model formulation. These determinants provide the mechanisms through which the observed child mortality levels could be explained and also how the desired mortality reduction can be achieved in the developing countries.

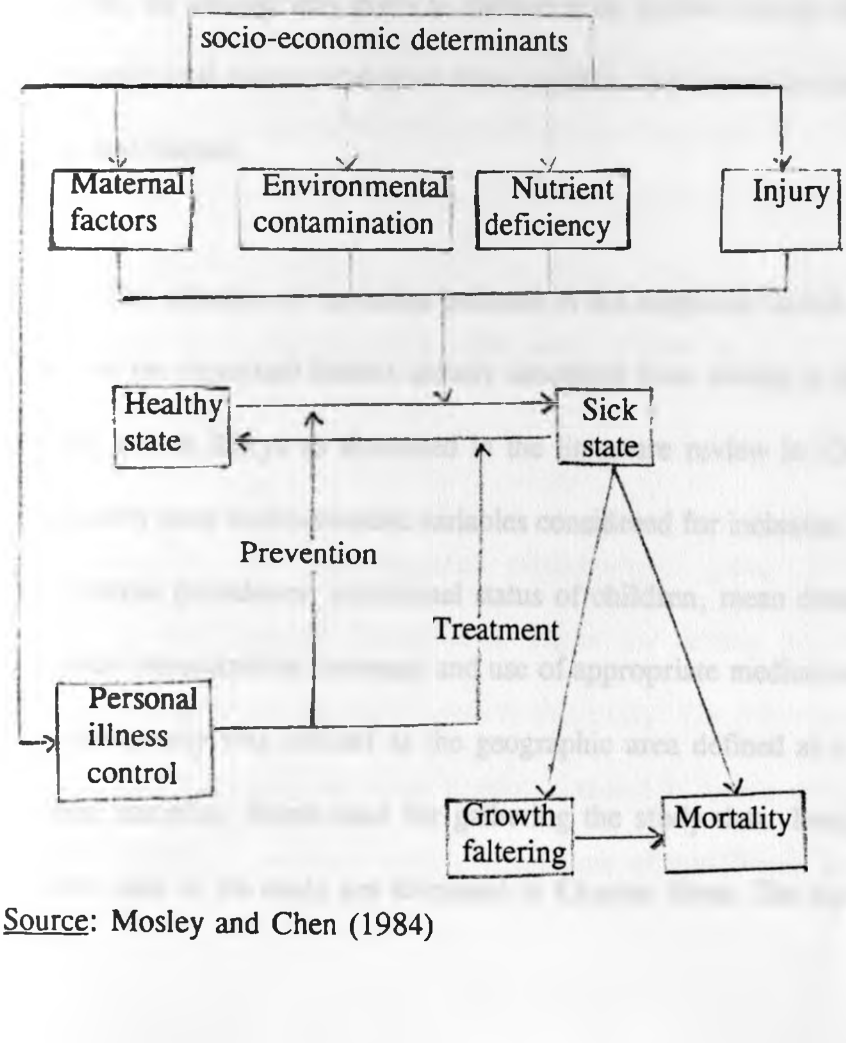
The first set of factors in the framework is called maternal factors, and consists of three variables namely age, parity and birth interval. These maternal factors have independent influence on the pregnancy outcome and on child survival because they affect maternal health. The second set, called environmental contamination factors, consists of four variables namely air, food/water/fingers, skin/soil/inanimate objects and insect vectors. This set of factors serves as agents of transmission of infectious, parasitic and viral diseases to children. The third set, called nutrient deficiency, consists of three variables which are also the three major classes of nutrients namely calories, protein and micronutrient. The nutrients available to the mother during pregnancy have an influence on foetal development while the nutrients available to the child have an influence on child survival after birth.

The fourth set of factors is called injury and consists of two factors namely accidental and intentional injuries. The physical injuries inflicted on children in a population whether accidental or intentional differ according to socio-economic and environmental contexts. The fifth and the last set of factors in this conceptual model is called personal illness control which consists of two factors namely personal preventive measures and medical treatment. Appropriate personal preventive measures drawn from the stock of the old traditional knowledge and from the new advanced knowledge on public health keeps an individual child away from disease while appropriate medical treatment returns the sick child to a healthy state.

The five groups of proximate determinants in this framework operate on the dynamics of a population in such a way that all the first four groups (consisting of a total of 12 factors) influence the rate at which the healthy children may shift towards sickness while the personal illness factors influence the rate of the incidence of illness (though prevention) and the rate of recovery from illness (through cure). The consequences of sickness may result in growth faltering or death as depicted in figure 2.1.

The Mosley/Chen conceptual model was adopted for this study with some slight modification to cater for the attainment of the objectives of this study. The slight modification made is inclusion of the additional premise that apart from the individual-level socio-economic determinants that must operate through the proximate determinants to influence child mortality, there is also the broad environmental context which provides the basis for the societal traditional public health knowledge and technology that must be supplemented (if existing traditional ones are appropriate) or replaced altogether (if traditional ones are inappropriate) by the modern ones at the individual level. The modification is therefore the expansion of socio-economic context to socio-economic and community level contexts. The operation of this modified model is similar to the original model except for the added dimension of interaction between the socio-economic and the community level environmental contexts. The empirical model used in the study and which was also derived from this modified Mosley/Chen conceptual model is discussed in detail in the next sub-section.

Figure 2.1 Mosley and Chen conceptual framework depicting operation of the five groups of proximate determinants on the health dynamics of a population



Source: Mosley and Chen (1984)

2.4.2 The Empirical Model:-

Due to limitations imposed by the nature of the cross-sectional data used in this study, a number of the individual level factors in the modified Mosley/Chen model were not incorporated in the analysis. The individual level factors not included in the empirical model used but which are in the modified conceptual model are factors in the groups of nutrient deficiency, injury and personal illness control for the individual children since this information was not available for the births that died prior to the date of the survey. However, an attempt was made to include these factors (except for injury) by using the community level measurements of these variables that served as part of the environmental contextual factors.

The selection of variables included in the empirical model used in this study was based on the important factors already identified from studies in developing countries in general and in Kenya as discussed in the literature review in Chapter one. The broad community level environmental variables considered for inclusion in the empirical model are malarial prevalence, nutritional status of children, mean duration of breastfeeding, complete immunization coverage and use of appropriate medical care in event of illness. The community was defined as the geographic area defined as a sample cluster in the national sampling frame used for gathering the study data. Details of the 326 sample clusters used in the study are discussed in Chapter three. The averages of the observed measurements from these clusters were assumed to reflect the sum of the traditional and modern advanced knowledge regarding public health and use of medical technology.

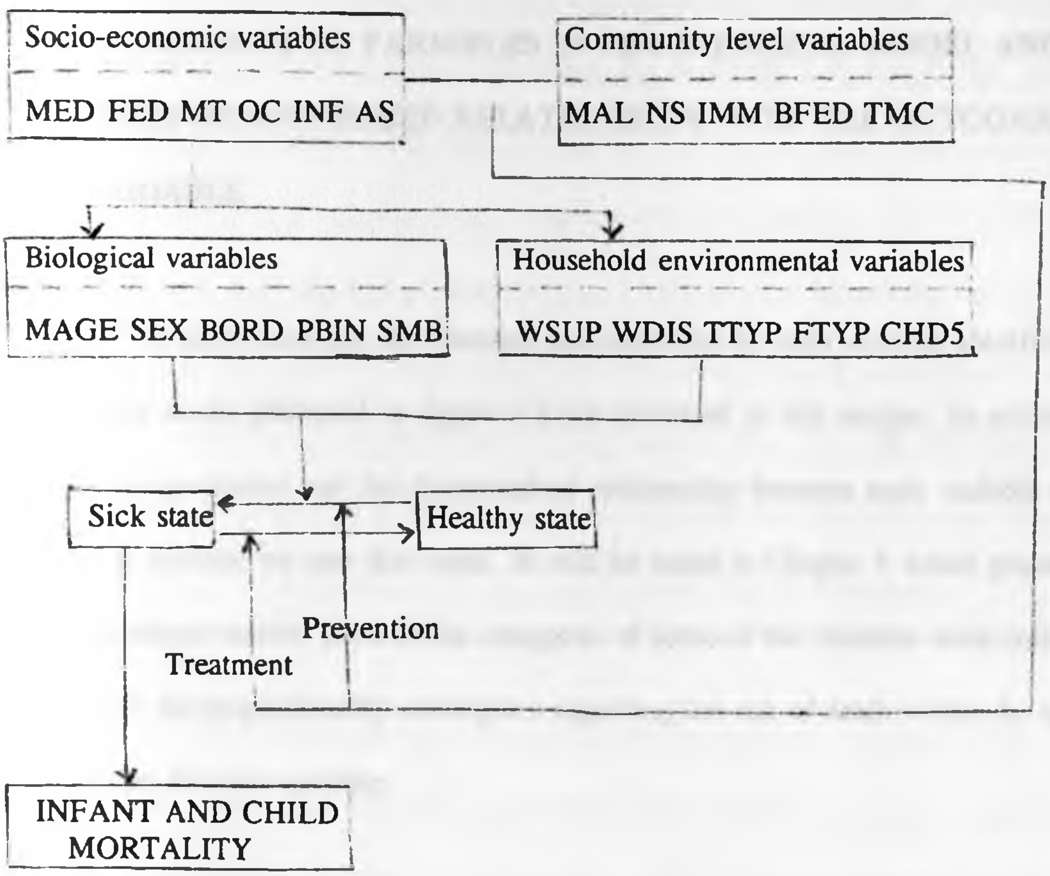
The socio-economic variables considered in the empirical model are education of the mother and father, husband's occupation, household assets, source of general information (accessibility to radio), and type of marriage unions (polygamous/monogamous).

The proximate variables considered in the empirical model consists of two groups, namely the maternal and the environmental contamination factors. The group of factors called maternal in the original conceptual model was renamed biological in the empirical model to accommodate inclusion of sex and type of birth (specifically whether single or multiple). The four variables that are considered under this category are mother's age at birth of the child, sex of child, birth order, preceding birth interval and birth type (single, multiple).

Similarly, the environmental contamination group of factors was renamed household environmental variables to allow for testing the hypotheses relating to household level environmental factors in this study. The five variables considered under this category are quality of water supply, distance to source of water supply, quality of housing, sanitation, and the number of children of age five or under in the household.

The outcome variable used in the empirical model was the risk of death during infancy and childhood up to age five years. The operations of the full empirical model and the variables used in this study are represented by the schematic diagram (figure 2.2). Specific details of what each of these variables was intended to measure and their hypothesized relationship with the outcome variable are discussed in the next section.

Figure 2.2 The empirical model used to study the impact of household and community levels environmental factors on infant and child mortality in Kenya.



KEY

MAL - Malaria prevalence
NS - Nutrition status of children
BFED - Mean breastfeeding period
IMM - Immunization coverage
TMC - Medical care provided to sick children

MED - Mother's education
FED - Father's education
OC - Husband's occupation
INF - Source of information
AS - Household assets
MT - Polygamous/Monogamous marriage

MAGE - Mothers age at birth of child
BORD- Birth order
PBIN - Preceding birth interval
SMB - Single/Multiple birth

WSUP - Water supply source
WDIS- Distance to water source
TTYP - Toilet facility type
FTYP- Floor material type
CHD5 - Number of children aged 5 years or under

2.5 DEFINITIONS OF VARIABLES IN THE EMPIRICAL MODEL AND THEIR HYPOTHESIZED RELATIONSHIPS WITH THE OUTCOME VARIABLE

The definitions and the intended measurements by each variable specified in the empirical model presented in figure 2.2 are discussed in this section. In addition, the initial categorization and the hypothesized relationship between each variable and the outcome variable are also discussed. As will be noted in Chapter 4 which presents part of the analysis results, some initial categories of some of the variables were collapsed to allow for the proportionality assumption regarding the risk of death within the specified categories for each variable.

2.5.1 The dependent (outcome) variable

The risk of death during infancy and childhood defined as any age under five years was used in this study as the outcome variable. The infancy and childhood period was divided into six segments to maintain the reversed J shaped age specific mortality pattern in the analysis. The segmentation of the period into six was based on the findings and recommendations from previous works that examined the effect of grouping of reported deaths in the calculations of mortality rates during infancy and childhood. Rustein's (1983) study based on the reported infant and child deaths contained in the World Fertility Survey data sets for 29 developing countries including Kenya, concluded that the effect of grouping of the reported deaths into six categories (0 completed months; 1 to 2 months; 3 to 5 months; 6 to 11 months; 12 to 23 months; and 24 to 59 months) was negligible when computed mortality rates results were compared for these groupings and for ungrouped data for the countries with least heaping (Rustein,1983, p. 9). Evidence on quality of reported deaths by age used in this study, as discussed in detail in Chapter 3, indicate that there was no substantial error as revealed by the study results on the analysis of completeness of age reporting and digit preferences.

The risks of death for each of the variable category was therefore defined in this study as the maximized likelihoods of the observed deaths in each age segment taking into account the total exposures (child-months lived) in the age segment. The dependent variable was specified in the regression model as the logarithm of the counts of event (death) in each age segment and the offset was the logarithm of the total exposures in the segment for each variable category. Details of the variable specifications in the regression model is discussed in Chapter 3. It was the expectation that the empirical age specific pattern of mortality during infancy and childhood would follow the reversed J shape.

2.5.2 Socio-economic variables

The socio-economic variables included in the empirical model were based on the reviewed literature discussed in section 1.3.3. Both the mother's and the father's education were initially categorized into four (none, 1-4 years, 5-8 years, and 9+ years) to cater for the differentials in infant and child mortality pattern established by recent studies [e.g Kibet, 1981; Mott, 1982; and United Nations, 1986]. The mother's and the father's education variables were intended to capture the knowledge level of child care with the underlying assumption that the higher the educational attainment, the better the child health care. The hypothesized relationship relating these education variables and the outcome variable was that the risk of death was expected to decline with the increase in the number of years of formal schooling.

The household assets and the husband's occupation variables in the empirical model were intended as a proxy for standard of living in the household. The initial three categories of the household assets variable were limited, average, and much assets. The computations for this variable were based on ownerships of various household assets such as land, cash crops and real estate (permanent house). The initial categorization of the husband's occupation was limited to five categories (none, all agriculture, skilled and unskilled, sales and service, professional and clerical). Details of categorizations and computations of these variables are presented in Chapter four. The basic premise was that occupational and household assets categories associated with higher incomes were assumed to lead to a higher standard of living and hence were expected to have relatively lower risk of infant and child death consistent with the established inverse relationship between mortality and income.

The source of information variable measured by accessibility to radio by the child's mother was intended to capture the rate of diffusion of advanced knowledge on medical technology. The initial three categories used were those who did not listen , those who listened but did not own, and those who did listen and owned radio. The assumption made was that the diffusion rate is higher for those who listen and own a radio, and is slower for those who do not listen at all to the radio. The expectation was that the risk of infant and child death would be lower for mothers who had more access to information.

The type of marriage (polygamous and monogamous) variable was intended to capture the effect of allocation of family level resources for child care as well as capturing the effect of cultural influences on risk of death at infancy and childhood. Children in monogamous families were assumed to have the complete access to all the resources that a family could devote for child care while those in the polygamous families were assumed to have only partial access (based on the understanding that the available family resources for child care would be split among the wives of the husband). The hypothesized relationship was that the risk of infant and child death was relatively higher for children in polygamous marital unions.

2.5.3 Community level variables

In this group of contextual variables, five variables were initially considered for inclusion in the empirical model. The basis for the selection was the availability of data for their computations and the review of the literature on this aspect of the study as discussed in section 1.3.4. These five variables were the computed cluster (community) averages of malaria endemicity, nutritional status of children , length of breastfeeding duration, complete immunization coverage and care provided to the children in event of illness. It should be noted that apart from the malaria and to some extent the immunization variables, the rest of the variables classified under this cagegory should not have been treated as community level variables if data were available at individual level.

Malaria endemicity was intended to capture health climate of the living environment with respect to tropical diseases. Malaria has been found to be endemic in hot humid tropical climates which are also favourable for other tropical diseases. Since it was not possible to obtain cluster level specific infections due to malarial parasites, the geographic location of the cluster with respect to the established zoning of malaria endemicity was used. As a general rule, clusters located in malaria endemic zones (such as the Lake Victoria Basin and the Coastal Belt) were considered in the analysis as communities where malaria was endemic while those in non-malarial endemic zones were considered as communities where malaria was non-endemic. This classification was also confirmed by personnel contacted who were involved in malaria research at the Kenya Medical Research Institute. The expected relationship was that the risk of death at infancy and childhood would be greater in malaria endemic environmental settings.

The average nutritional status of children was measured by the proportion of well nourished children in the cluster based on the anthropometric indices on age for height and height for weight computed as per the recommendations by the WHO (1990) discussed in Chapter 4. It was the expectation in this study that in community environments where most children were well nourished the risk of death, especially during childhood, would be lower since they would be less vulnerable to diseases arising from their enhanced higher level of natural immunity due to good nutrition. The computations and the categorizations of this variable are presented in Chapter 4.

The immunization variable was measured by the average immunization coverage for the cluster. This variable was intended to measure the level of immunization protection of the children against vaccine-preventable diseases. The underlying assumption was that children in environments where immunization coverage was high were better protected against these fatal diseases and therefore were at lower risk of death. The consequences of outbreaks of diseases such as measles would be more cases of infant and child deaths in environments with low or poorer coverage.

The mean breastfeeding duration in the community was intended to measure the relative level of natural protection against infections for the children. Longer breastfeeding periods have been established to be associated with higher natural immunity against infections due to the richness of the breastmilk content in nutrients. It was therefore the expectation in this study that children from communities with relatively shorter breastfeeding durations would suffer relatively higher risks of infant and child death due to their lower level of natural protection against infections. The detailed discussion on the computation and categorization of this variable is also included in Chapter 4.

Finally, under this category was the variable average medical care provided to the children in event of illness. This variable was intended to provide an aggregate measurement of the level of use of appropriate modern medical technology in the community. It was the expectation in this study that the risk of infant and child death would be relatively lower in community environments using mostly appropriate medical technology in event of illness of children. Information on the type of medical care provided to children reported to have suffered from specific infectious and parasitic diseases including fever within a two week period prior to the date of survey was used to determine the proportion of sick children provided with appropriate medical care in each community.

2.5.4 Biological proximate determinant variables

As was indicated in section 2.4 where the study conceptual model was discussed, the proximate determinants included were divided in two sub-categories, namely biological and household environmental. The selection of variables for the first sub-category was mainly based on the literature reviewed in section 1.3.2. The initial categorization of these variables was based on the established infant and childhood mortality patterns from these studies specific to Kenya and also from other relevant cross-national studies. The five variables considered under this sub-category were age of mother at child's birth, sex of the child, order of birth, preceding birth interval, and type of birth (single/multiple). The variable sex of the child was intended to measure the biological strength of the child. Evidence from the reviewed relevant studies established that male mortality is on the average in excess of female mortality at below age one year and then more or less similar after age one year. It was the expectation in this study that male mortality would be on average in excess of female mortality.

The birth order variable was intended to capture the biological strength of the child. In the literature review section, it was indicated that in Kenya there was some interaction between birth order, mother's age at child's birth and the socio-economic factors, and hence that the U shaped relationship that exists between order of birth and infant and child mortality was not obvious. It was therefore the expectation in this study that first and higher parity (5 and above) births would depict relatively higher risk of death.

On the basis of the reviewed literature, a U shaped relationship is expected between age of the mother at the time of the birth of the child and the risk of death during childhood, especially at infancy. This variable was therefore intended to capture the physiological strength of the mother which has an indirect relationship with the biological strength of the child. The three categories initially considered were ages under 20 years, 20-34 years and 35+ years. It was the expectation in this study that the U shaped mortality pattern would be depicted by these three categories of mothers age such that the young (under 20 years) and the old (35+ years) would have relatively higher child mortality compared to those in their prime reproductive years (20-34 years).

Although the general level of attention and health care provided to the child is a function of many variables, birth interval was identified from the reviewed literature to be an important risk factor. Children born less than two years after the birth of their next older siblings have been shown to have a relatively higher risk of death during childhood in Kenya (KDHS, 1989). The variable preceding birth interval was therefore intended to capture this effect. It was therefore the expectation in this study that births with shorter preceding intervals (under 24 months) would have relatively higher infant and child mortality and that the risk would decline with the increase in length of preceding birth interval.

The type of birth (multiple/single) was also introduced in the empirical model to measure the biological strength of the child. It was indicated in the literature review section that children from multiple births are more than four times as likely to die during infancy as singletons, and have also a substantially higher mortality during childhood. It was therefore the expectation in this study that the multiple births would have a relatively higher risk of death during infancy and childhood.

2.5.5 Household environmental proximate determinant variables

The five initial variables included under this sub-category were very central to the objectives of this study. Their selection was based mainly on the reviewed literature from Kenya and from other developing countries discussed in section 1.3.4. The variable type of water supply was intended to capture the risk of morbidity arising from use of contaminated water. Water obtained from pipes, bore-holes and from wells which were not open were considered to be less contaminated while the water obtained from other open sources such as rivers, lakes, open wells and dams were considered as more contaminated. The morbidity risk was assumed to have a direct relationship with the risk of death particularly after infancy so it was the expectation in this study that children from households using more contaminated water would have a relatively higher risk of death.

Distance to source of water measured in terms of travel time was intended to capture availability of water which in turn was anticipated to capture the hygienic condition of the household. It was assumed that shorter distance implied plentiful of water and consequently better hygienic household conditions. Travel time to water source of less than 30 minutes was considered short, 30 to under 60 minutes was considered long and distances of 60 minutes and over were considered very long. It was the expectation in this study that the risk of death during infancy and childhood would be higher for children belonging to households with longer distances to a water source and by implication higher risk for those children who were living in poorer hygienic household conditions.

Type of toilet facility and type of floor material for the dwelling household unit were also variables intended to capture the hygienic condition of the household. Hygienic toilet facility and modern dwelling units are key ingredients of public health and have long been associated with good hygienic conditions. It was therefore expected in this study that children belonging to households with better toilet facility and those belonging to households with modern dwelling units (as measured by the quality of floor material) would have relatively lower risks of death during infancy and childhood.

The last variable under this sub-category was the number of siblings aged 5 years and under in the household. This variable was intended to measure the rate of spread of infections in the household through finger and other forms of contact among the siblings in the household. It was assumed that the rate of spread of infection to an individual child is a function of the number of children aged 5 years and under in the household, such that the greater the number the greater the rate of spread and consequently the higher the mortality. In the initial classification, households with 4 or more siblings aged five years and under were considered to belong to the category with higher infection rate and those with not more than two were considered to belong to the category with lower infection rate. It was therefore the expectation in this study that the risk of mortality during infancy and childhood would increase with the number of siblings aged five years and under in the household.

In concluding the discussions on the definitions, measurements and hypothesized relationships between each of the explanatory variables and the outcome variable in the empirical model, it should be noted that these hypotheses were subjected to empirical tests using the methods of analysis discussed in detail in Chapter 3. The results are presented and discussed in detail in Chapters 4 and 5.

CHAPTER 3

DATA AND METHODOLOGY

3.1 DATA SOURCES AND STUDY SAMPLE

Data used in this study was obtained from two sources. The first source, which provided data on the individual and household level characteristics of the births, was the Kenya Demographic and Health Survey conducted between December 1988 and May 1989 by the National Council for Population and Development in collaboration with the Institute for Resource Development/Macro Systems, Inc. This survey (referred to hereafter as KDHS) gathered data on fertility, family planning and maternal/child health from 7,150 women aged 15 to 49 years. The KDHS sample covered 95 percent of the population. A total of 457 sample clusters (353 rural and 104 urban) were drawn out of 918 sample clusters (768 rural and 150 urban) in the master national sampling frame designed and maintained by the Central Bureau of Statistics, a department in the Ministry of Planning and National Development of the Republic of Kenya. The master sample frame used in the KDHS is called the Sample Survey and Evaluation Programme II and is also referred to hereafter as NASSEP II.

The second source which provided data used in this study to construct community level variables on nutritional status of surviving children was the Rural Nutrition Survey conducted by the Central Bureau of Statistics between November and December 1987. This survey is hereafter referred to as RNS. This study utilized only information collected using Module RN5 of the RNS that gathered data on immunization, breastfeeding and growth for 6,956 children aged 6 to 60 months. The RNS sample covered only the rural population (constituting about 80 percent of the total Kenya's population). A total of 689 rural clusters were drawn for this survey out of the 768 rural clusters in the national sample frame NASSEP II.

The data used in this study are a subset of data gathered in the two sample surveys (KDHS and RNS) restricted to 326 common rural clusters. The RNS did not have the urban component, so the information gathered in the urban clusters in KDHS could not be used in this study. In addition, information collected in 13 rural clusters (2 rural clusters in Busia District and 11 rural clusters in Bungoma District) in the KDHS could not be utilized because the RNS data collected from these clusters could not be read due to error in some sectors in the original computer diskette in which the data was copied at the Central Bureau of Statistics Office in Nairobi. Table 3.1 presents numbers of sample clusters used in the study relative to the NASSEP II frame and the sampled clusters in the KDHS and RNS. The KDHS sample had a bias on 13 rural districts thus, the very odd sampling relative to the NASSEP II frame reflected in table 3.1.

The matching of the two data sets was done using the variable cluster number which did not change in the two surveys done using the NASSEP II sample frame. The use of the information from the RNS was most appropriate since nutrition variables were central to the study and it was also within five years prior to the KDHS survey which did not gather data on nutritional status of the children.

Table 3.1 Sample clusters covered in NASSEP II, KDHS RNS and Study

Province	District	Number of clusters NASSEP II	RNS	KDHS	STUDY
Coast (Rural)	Kilifi	24	23	24	23
	Lamu	24	-	3	-
	Tana River	24	-	2	-
	Kwale	24	24	2	2
	Taita Taveta	24	24	2	2
Eastern (Rural)	Machakos	24	24	24	24
	Kitui	24	24	2	2
	Meru	24	22	24	22
	Embu	24	24	2	2
Central (Rural)	Nyeri	24	23	24	23
	Muranga	24	24	24	24
	Kirinyaga	24	24	24	24
	Kiambu	24	24	2	2
	Nyandarua	24	24	3	3
Rift Valley (Rural)	Nakuru	24	24	2	2
	Nandi	24	24	2	2
	Narok	24	24	2	2
	Kajiado	24	24	2	2
	Kericho	24	24	24	24
	Uasin Gishu	24	22	24	22
	Trans Nzoia	24	24	2	2
	Baringo	24	24	3	3
	Laikipia	24	24	2	2
	Elgeyo Marakwet	24	24	2	2
	West Pokot	24	-	2	-
Nyanza (Rural)	South Nyanza	24	23	24	23
	Kisii	24	24	24	24
	Kisumu	24	24	2	2
	Siaya	24	24	24	24
Western (Rural)	Kakamega	24	24	24	24
	Bungoma	24	24	24	13
	Busia	24	24	2	-
Urban Centers	All combined	150	-	104	-
TOTAL		918	689	457	326

Sources:- KDHS, 1989 Report and RNS, 1987 Field Report.

To facilitate the undertaking of multi-level analysis (individual/household and community levels) as per the design of this study, there was need to compute both community and individual/household level variables. The following information was utilized to compute community level variables :-

(i) all the 3444 cases of children aged 6 to 60 months in the 326 clusters in the Rural Nutrition Survey were used irrespective of their mother's marital status.

(ii) all the 6199 births that occurred since January, 1983 to all the ever married and the never married women in the 326 clusters in the Kenya Demographic and Health Survey.

On the other hand, information on all the 5,826 births that occurred since January, 1983 to ever married women in the 326 clusters in the KDHS was utilized to compute individual/household level variables.

The restriction of the analysis to the five-year period arose from the need to use information gathered in the KDHS on health and breastfeeding (such information was collected only for the births since January, 1983) and also to be assumed as constants over the period the household/individual level socio-economic characteristics observed at the end of the five-year period. Restriction to utilization of births to ever married women in KDHS stemmed from the desire to incorporate variables on husbands in this study.

3.2 BACKGROUND CHARACTERISTICS OF BIRTHS IN THE STUDY SAMPLE

The background characteristics of the births in the study sample were examined so as to provide a background against which the interpretation of the results of the analysis could be based. In addition, it was also thought that it would facilitate the undertaking of internal and external consistency checks of the sample data given the knowledge obtained from other published sources on rural Kenya. Restricting the study to births to ever married women meant losing some amount of information. In order to determine the amount of information lost, it was necessary to examine the distribution of the births in the sample with respect to marital status of the mothers at the time of the survey. Discussed below is the distribution of the births used in this study by age group of the births alive at time of survey or of the births dead prior to the survey, by marital status category of the mother at the time of the survey, and finally by some background characteristics of their parents and household amenities at the time of survey.

3.2.1 Age distribution of births reported alive and dead in the study sample

Information on ages of the births alive at the time of survey or the ages at death for the births dead prior to the survey was central to the computation of the dependent variable in this study. Although the assessment of the degree of the accuracy in age reporting will de discussed at a later section, table 3.2 gives a picture of age distribution in completed months for the births reported alive and those reported dead born to ever and never married women in the 326 rural clusters covered in the KDHS and in the study sample. In addition, the age distribution in completed months for children covered in the RNS sample restricted to the 326 common clusters is also included in the table.

Table 3.2 indicates that use of the study sample would have low age selectivity problem. The target population during the 1987 RNS were the children of age 6 to 60 months and this explains the very low percentage of children reported in the age groups 3 to 5 and 60+ months.

Table 3.2 Percent age distribution of births reported alive and dead in the KDHS (Rural), RNS and the study samples.

Age group in completed months	KDHS (rural) sample				RNS sample		Study sample			
	Alive		Dead		Alive		Alive		Dead	
	%	No.	%	No.	%	No.	%	No.	%	No.
Under 1	0.8	45	36.1	178	-	-	0.7	39	34.8	166
1 - 2	3.1	176	9.9	49	-	-	2.8	150	9.9	47
3 - 5	4.5	258	10.8	53	0.3	10	4.3	229	10.9	52
6 - 11	8.4	479	17.8	88	10.6	366	8.0	427	18.2	87
12 - 23	16.3	932	14.2	70	24.5	845	16.0	855	14.7	70
24 - 59	48.4	2773	10.3	51	62.7	2161	48.9	2616	10.7	51
60+	18.6	1064	0.6	3	1.8	62	19.3	1034	0.6	3
Missing	0.0	1	0.2	1	0.0	0	0.0	1	0.2	1
Total	100.0	5728	100.0	493	100.0	3444	100.0	5351	100.0	477

Sources: KDHS (Rural) and RNS samples restricted to the 326 common clusters.

3.2.2 Distribution of births by mother's marital status in the KDHS (Rural) and in the Study samples

Table 3.3 shows distribution of the births by mother's marital status at the time of the survey, and depicts the price paid for by restricting the analysis to only births to ever married mothers. The loss was 6.6 percent of the total births alive and 3.2 percent of the total births dead. On the overall, it could be concluded that the loss was not very heavy compared to the gain of being able to incorporate information on husband's characteristics in the analysis.

Table 3.3 Percent distribution of births in the KDHS (Rural) sample by mother's marital status

Mother's marital status	Births alive Percent	Births alive Number	Births dead Percent	Births dead Number
Never married	6.6	376	3.2	16
Ever married	93.4	5351	96.8	477
Missing	0.0	1	0.0	0
Total	100.0	5728	100.0	493

Sources: KDHS (Rural) sample restricted to the 326 common clusters

3.2.3 Distribution of births reported alive and dead in the study sample by some background characteristics.

The interpretation of the results as well as checking for their consistency requires information on the background characteristics of the births in the study data. In table 3.4, the following background information about the births are provided:- mother's age group in 5-years; mother's province of residence; mother's broad education attainment level; religious affiliation of the mothers; type of marital union of the parents; and father's broad occupation category. Table 3.5 contains information on the household level amenities for the births in the study sample.

Table 3.4 Percent distribution of the births in the study sample by background characteristics of the parents

Background characteristic	Births alive Percent	Births alive Number	Births dead Percent	Births dead Number
Mother's age group				
15 - 19	2.8	150	6.5	31
20 - 24	18.2	976	20.5	98
25 - 29	30.1	1611	26.8	128
30 - 34	20.7	1107	19.3	92
35 - 39	16.1	861	15.9	76
40 - 44	9.0	479	8.6	41
45 - 49	3.1	167	2.3	11

Mother's residence				
Central Province	20.4	1093	10.3	49
Coast Province	8.1	433	13.0	62
Eastern Province	17.2	923	10.9	52
Nyanza Province	19.3	1034	34.8	166
Rift valley Pro.	20.3	1085	8.6	41
Western Province	14.6	783	22.4	107
Mother's education				
No education	30.8	1648	37.3	178
Primary incomplete	34.0	1818	33.3	159
Primary complete	20.8	1113	18.4	88
Secondary +	14.3	766	10.7	51
Not stated	0.1	6	0.2	1
Mother's religion				
Catholic	32.6	1747	29.8	142
Protestant	58.9	3152	55.1	263
Muslim	2.9	155	4.8	23
Other	1.1	58	1.5	7
No religion	4.3	229	8.8	42
Missing	0.2	10	0.0	0
Marriage type				
Monogamous	75.4	4036	62.3	297
Polygamous	19.1	1024	31.0	148
Missing	5.4	291	6.7	32
Father's occupation				
Never worked	1.9	101	3.1	15
Professional	10.2	548	8.2	39
Clerical/Sales	13.8	736	8.4	40
Agricultural	40.9	2186	43.4	207
Domestic/Service	14.8	791	19.7	94
Manual	17.6	940	16.1	77
Missing	0.9	49	1.0	5
Total	100.0	5351	100.0	477

Source:- Study sample

From table 3.4 above, the following conclusions can be drawn on the characteristics of the parents of the births in the study:-

(i) the majority of the births occurred to mothers in their prime reproductive ages

(20 - 34 years), as was expected given knowledge of age pattern of fertility pattern in rural Kenya;

(ii) the births are nearly equally distributed regionally save for Coast Province;

(iii) about one third of the births occurred to mothers with no formal education and less than 15 percent occurred to mothers with secondary level of education or above;

(iv) over 80 percent of the births occurred to mothers who are christians, and less than 5 percent occurred to muslim mothers;

(v) about 70 percent of the births were born to mothers in monogamous marital unions;

(vi) almost half (over 40 percent) of the births occurred to fathers who were employees or self employed in the agriculture sector while the rest were distributed nearly equally in the other occupational categories.

Similarly, it is evident from table 3.5 that the data were from a typical rural setting in a developing country where ownership of land is universal with agriculturally based economy utilizing limited modern technological advancements. This is reflected by almost total non availability of electricity and negligible proportions using modern household equipments such as television and a refrigerator. Additional background characteristics of the household level amenities in the sample can be summarized as follows:-

(i) about one half of the births occurred to households with a radio or with some cash crop;

(ii) about 30 percent of the births occurred to households with a bicycle, a mode of transport commonly used in rural areas;

(ii) barely more than 5 percent of the births occurred to households with any of the three automobiles (motorcycle, car and tractor); and

(iv) barely more than one quarter of the births occurred to households with a permanent house.

Table 3.5 Distribution of the births in the study sample by household amenities

Amenity	Births alive		Births dead	
	Percent	Number	Percent	Number
Without electricity	97.8	5235	98.7	471
With radio	56.3	3012	46.1	220
With television/fridge	1.9	103	1.7	8
With bicycle	28.7	1537	23.7	156
With any automobile	5.4	291	3.4	17
With land	92.8	4965	95.2	454
With farm animals	81.3	4350	70.6	337
With cash crop	49.1	2629	41.9	200
With permanent house	25.6	1370	15.9	76

Source: Study sample

3.3 QUALITY OF THE STUDY DATA

Since the dependent variable of the study was risk of death at specified age segments, assessment of age reporting for the births alive and births dead at the time of the survey was a central issue in this study. The quality of the data used was assessed using both internal and external checking procedures. The internal checks were done by examining age reporting of the study sample births and deaths while the external checks were done by comparing some of the rates obtained using the sample data and those contained in relevant published documents on rural Kenya. The assessment of the quality of the reported information on socio-economic conditions (such as educational attainment of parents) and the household level environment (such as type of toilet facility) could not be carried out because of lack of suitable comparable data and were therefore assumed to have been reported and recorded correctly during the field work.

3.3.1 Completeness of age reporting

The reported birth dates for the 5826 births used in the study were of good quality in general when the proportion of non imputed dates was applied as a crude measure of completeness of age reporting. Table 3.6 shows that 98 per cent of all the 5826 births did not have their birth dates imputed (implying that the month and year of each were reported by the respondents); 1.7 per cent of the births had their birth dates partially imputed (implying that the month could not be provided by the respondent); and only 0.1 per cent had their birth dates fully imputed (implying that the respondent could not provide information on year of birth). Age reporting for the 3444 births drawn from RNS data that were used in the study to compute community level nutrition variables was relatively of poorer quality when compared to the 5826 births drawn from the KDHS: about 12 per cent had their birth dates partially or fully imputed. Reporting in the KDHS of age at death was also good: none of the 477 reported deaths used in this study had the age at death imputed.

Table 3.6 Percent distribution of age reporting of births and deaths used in the study

Imputation of dates	Births alive Study sample percent	Number	Children RNS sample Percent	Number	Deaths Study sample percent	Number
Not imputed	98.2	5726	87.8	3024	100.0	477
Partially	1.7	98)			0.0	0
Fully	0.1	4)	12.2	420	0.0	0
Total	100.0	5828	100.0	3444	100.0	477

Sources: Study and RNS samples restricted to the 326 common clusters.

3.3.2 Age Heaping of the reported births and deaths used in the study

The assessment of age heaping of the reported births and deaths used in the study was done by plotting the reported current ages (in completed months) for the births that were alive at the time of the survey. For the children reported dead by the time of the survey, reported ages at death were plotted. Overall, there was little evidence of systematic heaping of the reported ages on any digit number for the 5826 births drawn from the KDHS. Appendix Figure 3.1 show that there were some differentials in age heaping by sex. There was less heaping of reported ages for the males (heaping noted at ages 5, 17, and 54) than for the females (heaping noted at ages 2, 5, 7, 30, and 51).

The 3444 births drawn from RNS showed some evidence of age heaping at the months marking the end of completed years that was at 12, 24, 36, and 48. However, there were little evidence of differentials in age heaping by sex as depicted in Appendix Figure 3.2. Appendix Figure 3.3 shows the ages at death for 422 children reported that occurred at ages under 24 months used in this study. It shows evidence of age heaping at 12 months and little evidence of differentials in age heaping by sex. KDHS collected year of age at death for 2 and over, so it was not logical to assess heaping for months over 24.

3.3.3 Some external checks on data quality

The data used in this study did not cover all the master sample clusters in rural Kenya. The comparisons of the rates obtained using the study data with other rates obtained from other relevant published documents on rural Kenya are intended to provide some indications of the representativeness of the study data. The rates used for the comparisons are infant mortality rate, completeness of full immunization coverage and the mean duration of breastfeeding in months. The computed infant mortality rate using the study data and based on the method of data analysis in this study (proportional hazards model) was estimated at 63 per 1,000 live births which compared very closely with the estimate of 60 per 1,000 live births for the rural Kenya (KDHS Report 1989, p.57). The estimate of full immunization coverage based on the study data was 63 per cent while for the entire rural Kenya it was 61 per cent (Boerma et al. , 1990, table 4.1, p.10). The estimate of mean duration of breastfeeding in the last closed birth interval from the study data was 15.5 months which was on the lower side when compared with 19.1 months obtained using an indirect method (incidence-prevalence approach). The mean breastfeeding duration for rural Kenya measured via incidence-prevalence approach is 19.4 months (KDHS, 1989: p.15). It was not possible to use the indirect approach to estimate mean breastfeeding durations for each of the clusters due to few cases of births.

On the basis of the assessment results on completeness and heaping of age reporting as well as the external checks discussed above, the quality of the data used in the study can be said to be reliable in general. However, some evidence of heaping of the reported deaths especially at age 12 months could have biased the results of the computed risk of death in two age segments (5 to 11 and 12 to 23 months). The evidence of heaping of the reported age for the children drawn from the RNS data and the relatively lower degree of completeness of their age reporting could have also biased the computed results on the nutritional status of the children.

3.4 METHOD OF DATA ANALYSIS

3.4.1 Review of the available methods and the preferred method

The first method that has traditionally been used to study mortality by demographers is the ordinary life table. For the objectives of this study to be realized with this method, it would have required the construction of life tables of the several covariates simultaneously. This would have been impossible. The matrix of observations by the several covariates would contain too many cells with small numbers of observations to allow for reasonable life table analysis. The ordinary life table method suffers from the limitation of its assumption that the conditional probability of dying at a given age interval is the same for all individuals.

The second option is the group of indirect demographic techniques for calculating the probability of death during childhood based on information on the survival status of the children of women in the reproductive ages cross classified by the various covariates. This was the approach used by Meegama (1980) in his study of Sri Lanka. This approach can best evaluate at most two factors simultaneously due to required large sample sizes and for that reason was not suitable for this study. Also considered as a member of this category of approach was Preston and Trussell's (1982) method that utilizes, in addition, information on assumed age specific fertility and mortality patterns for women in their reproductive ages to calculate expected proportions dead of the children ever borne by women classified by age or duration of marriage group. This method uses individual women's birth and child death counts which are then regressed with the individual woman-specific covariates. Apart from the limitation that results obtained using this method may suffer from in correct fertility and mortality schedules adopted in the calculations, the method is woman based and cannot incorporate child-specific characteristics.

The third approach option is the use of analysis methods with the child as the unit of analysis. Under this approach we have ordinary least square, logit, and log-linear regressions. The assumptions of the ordinary least square are inappropriate for a (0,1) dependent variable. The logit regression is appropriate for a (0,1) dependent variable and the covariates of the child for each specified age segment. However, use of logit regression would not have allowed analysis for all the age segments simultaneously. The final option under this category is the use log-linear regression analysis in which the conditional probability of dying during a given age interval is assumed to differ between individuals with different socio-economic or demographic characteristics. This is a proportional hazards model which was first proposed by Cox (1972) and later lengthily described in terms familiar to demographers by Trussell and Hammerslough (1983). One can also use age-specific hazards models without proportionality assumptions. The hazards model was preferred for this study because it allows for the simultaneous incorporation of all the age intervals in the regression analysis and also allows for the utilization of both uncensored and censored survival cases in the data set.

3.4.2 Definition and assumptions of a hazards model

The term hazard in ordinary use mean risk. A hazards model is therefore a model that defines the risk of instantaneous occurrence of a given event. In the analysis of survival data, an event such as death of an individual can be viewed as a failure with the time at death of that particular individual being viewed as the failure time and the total duration of time lived by that particular individual viewed as the survival time. A mathematical expression defining the instantaneous risk of failure at any given time can be written to depict the distribution of the occurrence of the failure event over time (referred to in mathematical statistics as the density function) with another depicting the survival rate up to the observed time of the individuals in the population. Below are the mathematical formulations that are useful in the mathematical definition of hazards function.

Let T be a random non-negative variable representing lifetimes of individuals in the population.

t be the failure time for the individual.

S(t) = Survival function defined as the probability that the survival time will be greater or equal to the failure time.

$$= \text{Prob } (T \geq t) \text{ assuming that } S(0) = 1 \text{ and } S(\infty) = 0 \qquad (1)$$

f(t) = Density function.

$$= \lim_{\Delta t \to 0} \frac{\text{Prob } \{\text{failure occurs in interval } [t, t+\Delta t]\}}{\Delta t} \qquad (2)$$

h(t) = instantaneous failure rate or hazard function

$$= \lim_{\Delta t \to 0} \frac{\text{Prob } \{\text{failure occurs in interval } [t, t+\Delta t] \text{ given individual survived up to } t\}}{\Delta t}$$

$$= \lim_{\Delta t \to 0} \frac{\text{Prob } \{\text{failure occurs in } [t, t+\Delta t] \mid T \geq t\}}{\Delta t} \qquad (3)$$

The hazard function can be re-expressed further by using the classical definition of the conditional probability. The conditional probability of event A occurring given that event B has occurred is expressed as follows:-

$$\text{Prob}\ [A|B] = \frac{\text{Prob}\ [A \cap B]}{\text{Prob}\ [B]} = \frac{\text{Prob}\ [A \text{ and } B]}{\text{Prob}\ [B]} \quad (4)$$

The hazard function above can similarly be expressed as follows:-

$$h(t) = \lim_{\Delta t \to 0} \frac{\text{Prob}\ \{\text{failure occurs in } [t,\ t+\Delta t] \text{ and } T \geq t\} / \Delta t\}}{\text{Prob}\ \{T \geq t\}}$$

$$= \lim_{\Delta t \to 0} \frac{\text{Prob}\ \{\text{failure occurred in } [t,\ t+\Delta t] / \Delta t\}}{\text{Prob}\ \{T \geq t\}}$$

since we know that the individual survived up to time t.

$$= f(t) / S(t) \quad \text{using the formulations above.} \quad (5)$$

A hazard function has the following attractive properties that can be made use of in analysis of survival data:-

(i) its cumulative hazard function $\int_0^t h(u)du = -\log S(t)$ (6)

(ii) $h(t) \geq 0$ (7)

(iii) $\int_0^\infty h(u)du = \infty$ (8)

Property (i) above allows the study of survival function using the cumulative hazard function while the properties (ii) and (iii) provides the crucial constraints in hazard modelling.

When modelling failure time, say t, of a specified event over the population's survival time, say T, using hazards approach, knowledge of the distribution of the failure time is crucial if the estimation of the hazard is to be done through parametric statistical inference. The relatively more attractive and commonly used family of distributions is the exponential distribution which has a constant hazard. Other distributions can also be used except that the estimation of the hazard involves estimation of more than one other parameter and this complicates the estimation process. These other distributions have been proved to approximately reduce to the exponential distribution if the observed failure time interval is restricted to be small. The second and also commonly used distribution is the general family of distributions called Lehmann or proportional hazards which assumes that the hazard function is proportional to an unspecified baseline hazard but influenced by a function of a vector of explanatory variables as given below.

$$h(t,\underline{X}) = h_0(t)\, U(\underline{X}) \qquad (9)$$

where $h_0(t)$ is the baseline hazard,

$U(\underline{X})$ is a function of vector of explanatory variables.

The function of the explanatory variables $U(\underline{X})$ can be parameterized by assuming an exponential distribution as a special useful case, hence, the proportional hazard function above becomes:-

$$h(t,\underline{X}) = h_0(t)e^{\underline{B}\,\underline{X}} \qquad \text{where } \underline{B} \text{ is a vector of coefficients} \qquad (10)$$

The exponential distribution is assumed in the above proportional hazards function because of the reasons discussed above. In addition, the proportional hazard model is preferred due to easy interpretation of the effects attributed to any particular explanatory variable; and it accommodates censoring in statistical inference.

In modelling risk of death during infancy and early childhood, we will assume that mortality decreases with increase in age and roughly follows an exponential path. We will also assume that hazard can be lowered or raised by factors such as socio-economic and environmental conditions. Hence the use of proportional hazard function in this study.

The next task is to choose the form of regression model for the hazard function for convenient analysis of the outcome variable for this study. That is to say, a regression model that would not give undesired negative estimated hazard and also a regression model that would facilitate obtaining proportional hazards for the various categories of the explanatory variables to be included in the analysis. To avoid obtaining negative predicted values of the outcome variable, either a logarithmic transformation of the proportional hazard function yielding a log-linear regression model or a logit transformation of the proportional hazard function yielding a logit-linear regression model would be necessary. Since the response variable in this study was not chosen to be dichotomous, log-linear regression model is preferred. The regression model used in the study is specified below:-

$$\log h(a) = \log h_0(a) + B_1X_1 + B_2X_2 + \dots + B_kX_k \qquad (11)$$

where h(a) is the hazard at any age a

$h_0(a)$ is the baseline hazard

X_i are the explanatory variables

B_i are the regression coefficients

The log-linear regression model used in this study assumes discrete failure time and categorical time-independent explanatory variables. The discrete form was adopted due to the nature of the data used in the study and also the demand by the computer package GLIM which uses a contingency table approach to perform the algorithm necessary for estimation of the required parameters in the model. The contingency table approach requires that all the explanatory variables be categorical.

The assumptions of the log-linear regression model used in this study can be summarized as follows:-

(i) that the hazard is constant within each given age interval. This assumption requires that the age segments chosen must reflect the true shape of the age pattern of infant and childhood mortality.

(ii) that all individuals with the same covariates have identical hazards in any given age interval. This assumption of homogeneity among members of a distinct group in the age interval and heterogeneity among members of different distinct groups is a subject of debate and research since it ignores possibilities of differences in frailty due to individual or family, biological or genetic background.

(iii) that there is proportionality of hazards for individuals belonging to distinct categories of any given explanatory variable in any given age interval. This assumption may not hold in real situation for all the variables in all the age segments, hence the problem of dealing with some crossing hazards. Since this proportionality assumption of the hazards for the distinct categories of the variables included in the study was crucial, it was necessary that this be tested on the data used in the study. This assumption was tested by plotting the cumulative hazards for the categories of each variable in each of the six age segments used in the study. Some of the initial categories of the explanatory variables in the study were collapsed to facilitate conformity to the proportionality assumption of the hazards.

(iv) that the socio-economic variables and household level amenities influencing the baseline hazard are fixed over the time period January, 1983 to the date of the survey. This is not a very realistic assumption since it is a well known fact that rapid developments in socio-economic conditions occurred over this period. Thus the observed household amenities at the time of the survey partially reflect changes over the previous five years. This is particularly so for the rural areas since 1983 was the year when the district focus strategy for rural development was launched. For this reason, this assumption would lead to a failure to reflect the poorer past settings for the births aged one year or over at the survey date. This would not have been a problem if longitudinal data for these variables was available, since it would have been possible to undertake a proportional hazards regression with time-dependent covariates. Unfortunately the data used in this study had only information as of the date of the Kenya Demographic and Health Survey.

3.4.3 Estimation of parameters and hypothesis testing using hazards regression model

Hazards regression model uses an estimation procedure, known as maximum likelihood estimation (MLE), to estimate the unknown parameters in the model and to test the explanatory power of the model. Maximum likelihood estimation procedure involves obtaining a function that describes the probability or likelihood of observing the particular actual experience for all the individuals in the sample. This in effect is equivalent to obtaining a joint probability function which is referred to as a likelihood function. Maximum likelihood estimates of the parameters of a regression model are those values of the parameters that maximize the likelihood function and therefore maximizes the probability of observing the outcomes that did occur. In this study the outcomes were occurrence of death or survival of births in each of the specified age intervals.

The estimation and hypothesis testing using hazards models became possible following the work of Cox (1972) when he derived a very useful mathematical equation for a likelihood function of a proportional hazards model. Cox proved that the likelihood function of a proportional hazards function is equal to the partial likelihood and a residual likelihood that can be ignored without causing much error in the results of the analysis.

The result by Cox is useful because the partial likelihood involves only the parameters of major interest and the method works well for right censored data. In order to avoid dealing with cumbersome multiplicative nature of the partial likelihood function, its natural logarithm is normally used for its convenient additive property. The parameters that maximize the partial likelihood function also maximizes the partial log likelihood function. To maximize the partial log likelihood function one only needs to take the derivative (an operation in differential calculus) with respect to each of the parameters and set the result to zero.

Partial likelihood method also works for discrete or grouped data but with some modification to cater for the problem of ties introduced through grouping of the survival times. Thus the maximum log likelihood estimates for the parameters in the equation can be estimated using the observed information on the number of deaths and the number of total exposures for each of the specified age segments further cross-classified by all possible combinations of the covariates.

The maximization and estimation algorithm can be performed using special computer packages such as the GLIM package used in this study. The GLIM package uses matching of marginal criteria as used in log linear contingency table analysis. A contingency table by definition is a table of cells with one cell for each combination of the categories of the variables or factors. In this particular analysis, the estimated coefficients for the parameters must fulfil the condition that the expected number of deaths (or expected risk of death) for all the age intervals must equal the actual number (or actual risk of death) and similarly the expected number of deaths (or expected risk of death) for individuals with a specified characteristic must equal the actual number (or actual risk of death). Since the number of parameters to be estimated depends on the number of variables in the model, analysis involving categorical variables may generate many parameters because the number now becomes a function both of the number of variables and of the number of categories for each.

In order to be able to use the GLIM package for parameter estimation and hypothesis testing in hazards modelling, a GLIM data file was required for this study. The first step in the preparation of the GLIM data file was the calculation of deaths and total exposures in months for each of the six age segments chosen for this study and cross-classified further by all the possible combinations of the categorical explanatory variables included in the analysis. Births that survived the interval contributed the total number of months of exposure in the age interval while births that died in the age segment contributed only the months lived in the segment as the months of exposure in the interval. Births that occurred during the month of the survey were eliminated from the calculation of deaths and exposures in the first age segment (under one month) to avoid possible biases in the calculation of risk of death in this age segment. In addition, the majority of the births reported to have died in the first age segment (under one month old) were assumed to have died within the first one week and hence were assumed to have only contributed one quarter months of exposure in that age segment. Births who survived to 60 months and over contributed a number of months of exposure in each of the age segments equal to the total width of the age segments.

The second step in GLIM data file preparation was the elimination of the cells that contained zero exposures which could have arisen from the situation of having no births in the cell's variables combination. Elimination of the cells with zero exposures does not affect the likelihood function and assists in minimizing computing cost. The third and final step involves the production of a single GLIM data file for all the non-zero cells with each cell (also referred to as unit observation) having specific information on the observed number of deaths, total exposures and all the categorical variables characteristic of the cell. The hazards regression analysis was then done by specifying the logarithm of the observed number of deaths as the dependent variable, the logarithm of the total exposures as the offset and by using logarithmic link function with poisson error distribution.

The parameter estimates obtained using maximum log likelihood estimation procedure can be used to construct life tables and to assess the relative risk of death. To illustrate this point, a simple proportional hazards model in log linear format with only three of the variables used in this study is used for purposes of convenience and simplicity.

Let A_i be estimated coefficients for six age segments (1=under 1 2=1 to under 3; 3=3 to under 6; 4=6 to under 12; 5=12 to under 24; 6=24 to under 60) in months.

M_j be estimated coefficients for mothers education category (1=no education; 2=1 to 8 years; 3=9+ years)

F_k be estimated coefficients for fathers education category (1=8 or less years; 2=9+ years)

$\log(U_{ijk})$ be natural log of risk of death in age interval i for children with ijk characteristics.

Then the simple regression model can be written as follows:-

$$\log(U_{ijk}) = C + A_i + M_j + F_k \quad (i=1..6;\ j=1..3;\ k=1,2) \qquad (12)$$

where C is a constant term (equivalent to the grand mean effect)

Then to obtain the life table probability of surviving through age interval 4 (that is through infancy, denoted by P_4) can be given by the following demographic formula:-

$$P_4 = \exp\left[-(f_1U_{1jk}) - (f_2U_{2jk}) - (f_3U_{3jk}) - (f_4U_{4jk})\right] \qquad (13)$$

where f_i are the span in months in interval i

$$= \exp \{ [-1 \exp (C+A_1+M_j+F_k)] - [2 \exp (C+A_2+M_j+F_k)] - [3 \exp (C+A_3+M_j+F_k)] - [6 \exp (C+A_4+M_j+F_k)] \} \quad (14)$$

If the analysis is restricted to determining the effect of age interval only then the coefficients of the other covariates are assumed to be zero. If separate life tables are to be constructed for each of the covariates then the coefficients of the covariates not desired at every stage are assumed to be zero.

The main effects of the age interval and the covariates to relative risk of death can be assessed by examining the sign directions and magnitudes of their coefficients' estimates obtained from the maximum log likelihood estimation procedure. The GLIM computer package used in this study normalizes the effects estimates so that the sums of the age and other covariates (A_i, M_j and F_k) are each equal to zero using the first category entered in the model for each of the covariates as the reference categories. In this study, the category of each variable with the highest observed risk of death was specified in the model as the reference category. The obtained coefficient estimates are interpretated as follows: a positive estimate indicates that the risk of death is higher relative to the variable's reference category; a negative estimate indicates that the risk of death is lower relative to the variable's reference category. The quantitative effects of the covariates relative to the each other can be judged by the relative sizes of the differences between their estimates. Exponentiating the obtained estimated coefficients for each of the categorical variables in the model gives their relative risk of death to their reference categories.

There are two main issues that require testing when using any statistical model. The first issue is to be able to test whether the model fits the data adequately, that is to say, whether the variables contained in the model and the terms as specified in the regression model fit the data adequately. This is a crucial process for model selection in terms of determination of significant independent and or interaction of variables to be included in the analysis. The second issue is to be able to test for the statistical significance of the individually estimated parameters in the selected model.

To test the first issue in hazards regression, the likelihood ratio test is the most recommended procedure for testing the fit of the model. In the likelihood ratio test procedure, maximum likelihood estimate of a larger model (referred to as the unrestricted model) is compared with the maximum likelihood estimate of a smaller model (referred to as the restricted model) which must be a proper subset of the larger model. The idea here is that the maximized log likelihood in the restricted model cannot be larger than the maximized log likelihood in the unrestricted model, hence, the null hypothesis tested (H_0 : Unrestricted model = Restricted model) can be rejected if the value of maximized log likelihood for the unrestricted is less than the value for the restricted model. It has been established by the mathematical statistical theorists (for instance, discussions in Mood et al., 1974: pp.440- 442) that the testing statistic (denoted by U) relating the maximized log likelihood values for restricted and unrestricted models given in the expression below is distributed asymptotically as a Chi-square variate with degrees of freedom equal to the difference in the two models.

$$U = -2\{\max LL \text{ (restricted)} - \max LL \text{ (unrestricted)}\} \qquad (15)$$

where max LL denotes maximum log likelihood

The GLIM package used in this study gives the value of the testing statistic directly (labelled as scaled deviance) and also the degrees of freedom used in the estimation. The proportional hazards models containing all the variables in the analytical structure for each of the analytical models ran were used as the unrestricted models while the analytical models with one variable omitted at each stage were used as the restricted models. If the difference was found not to be significantly different from zero, then the restricted model was accepted to fit the data equally well as the unrestricted model and hence the omitted variable was said not to be a significant explanatory variable.

However, the rule of parsimony was applied prior to discarding a variable that was a candidate of being discarded. This became necessary due to the relatively very large degrees of freedom, arising from the large number of parameters especially in the full model, that could have resulted into rejection due to statistical insignificance in disregard of the theoretical or study importance of the variable. The study focused on the main effects models since these are easier to interpret when compared with interaction models. The scaled deviances of the main effect models ran and their corresponding degrees of freedom were also used to perform the statistical significance tests for these models.

The second issue was addressed as follows. The tests of significance between differences of effect estimates for each of the categorical variables were done by assuming asymptotic normality and hence using t-distribution calculations based on dividing the coefficients of estimates of the parameters by the standard errors of the estimates. A covariance term should have been included in the sum in the denominator for more accuracy but could not be done because the GLIM computer package used do not provide output for covariance terms. The t-test is exact for classical linear models but only justified for use in hazards regression models by the asymptotic theory of statistics. As a general rule of thumb, any estimated parameter less than its standard error is usually statistically insignificant while a parameter more than three times its standard error is usually statistically significant at 99 percent level of confidence. However, the calculated individual value of t-statistic provide a better and a more useful guide to test of significance especially when correlations between the estimated parameters are small.

The other alternative approach for testing the significance of effect for each of the categorical variables would be to run a model including the category of the variable whose impact's significance is to be determined and then re-running the model having the category of the variable now collapsed with the another category of the same variable and thus proceed to perform the usual Chi-square test. This second approach was not preferred in this study due to the prohibitive computing costs associated with it especially when running larger hazards models as was the case in this study.

3.5 STRATEGY FOR FITTING SUB-MODELS AND FINAL ANALYSIS MODEL

It was necessary to fit separate sub-models prior to the fitting of the final analysis model in order to be able to answer the research questions of this study adequately using the analytical framework adopted and discussed in detail in Chapter two. The strategy of fitting sub-models prior to the fitting of the final model was specifically aimed at:- determining the explanatory power of the individual sub-models and of each variable included the sub-models so as to facilitate ranking them with respect to their impact on the outcome variable; assessing the direction of effects to determine whether they were as expected based on theory; assisting in screening the variables so as to select those to be included in the final model; and in assessing the associations if any among the independent variables included in the multivariate sub-models. The three sub-models fitted were:-

(i) the model with the risk of death as the outcome variable and with all the household level environmental and other proximate determinants found to be associated with the risk of death from the univariate analysis.

(ii) the model with the risk of death as the outcome variable and with all the socio-economic variables found to be associated with the risk of death from the univariate analysis.

(iii) the model with the risk of death as the outcome variable and with all the community level environmental variables found to be associated with risk of death from the univariate analysis.

In fitting the above sub-models, the model containing all the variables under each group was treated as the unrestricted model while the models with one of the variables omitted at each stage of the analysis were treated as the restricted models. Chi-square statistical tests were performed at each stage to determine the significance of the variables in the sub-models.

The strategy adopted to fit the final full model was first to select the model by re-screening all the selected variables from all the three sub-models so as to determine the important variables to be retained in the full model. The model with all the selected variables from the three sub-models was used as the unrestricted model while the models with one of the variables omitted at each stage were used as the restricted models. This step also facilitated analysis of associations between the independent explanatory variables and thus determined the variables to be excluded and interacted in the final model.

The second strategy adopted facilitated determination of the order in which the variables were to be entered in the final model. This was the use of the "chunkwise" method. The three sub-groups were considered as chunks of variables that were related and of equal importance at the three levels of the analysis and hence were to be entered as chunks in the final model but while being guided by the analytical framework of the study. The chunk of variables containing age interval and the community level environmental factors was entered first then followed by the chunk of the socio-economic variables and finally followed by the chunk of household level environmental and other proximate variables. The chunkwise method for entering variables in the analysis has the advantage of incorporating prior scientific knowledge and hence facilitating the study of the mechanism through which sets of variables act to influence the outcome variable. It should be noted that although adjustments were not made in this analysis to cater for the correlated individual children in the households and in the communities due to lack of a suitable statistical package, the estimates obtained are still unbiased.

In this study, the chunk method adopted in entering the variables in the final model facilitated the analysis of risk of death using the framework of the socio-economic proximate determinants of child mortality while at the same time taking into account the contextual setting. This strategy also reduced the number of the models that were to be finally evaluated to only three instead of over ten if the selected variables that were to be included in the final model were not grouped into three chunks. The results obtained by use of the study data and the methods of data analysis described in this chapter are presented and discussed in Chapters 4 and 5.

CHAPTER 4

INFANT AND CHILD MORTALITY ESTIMATES AND DIFFERENTIALS BY ENVIRONMENTAL AND OTHER FACTORS

4.1 INTRODUCTION

The procedures used to compute the risk of death and survival probabilities in each of the six age segments used in this study was discussed in detail already in Chapter three Section 3.4.3. The initial categories for each of the 21 explanatory variables used in this study were also presented in Chapter two Section 2.3. The succeeding section presents estimates and univariate differentials in infant and child mortality by each of the variables used in the analysis. However, the initial categories for some of these variables had to be collapsed to conform to proportional hazards assumption.

The standard procedure to test for the proportional hazards assumption is to plot the computed natural logarithm of the negative natural logarithm of the empirical survival probabilities from birth, denoted by l_x in the life table. This procedure was used here. For the proportional hazards assumption to hold, the obtained plots of log(-log) of the survival probabilities from birth (which are essentially the cumulative hazards up to the specified ages) for the categories of each variable should lie parallel to each other. In this study, the life table survival probabilities from birth were computed using interval-specific hazards rates and the formula provided in Section 3.4.3. The log(-log l_x) values for each of the variable categories are for six ages corresponding to the start of succeeding age intervals (that is at ages 1, 3, 5, 12, 24 and 60 months).

The infant and child mortality estimates obtained in this study are compared with results from other studies in Section 4.2. In section 4.3 in this chapter, the results of the "univariate" models run to determine significant factors associated with risk of death during infancy and childhood as the outcome variable are presented. The term univariate is placed in quotes because of the inclusion of age interval variable as a control variable in each of the models.

4.2 INFANT AND CHILD MORTALITY ESTIMATES AND DIFFERENTIALS

4.2.1 Age pattern of infant and child mortality

The infancy and childhood period in this study has been subdivided into six segments in order to maintain the expected reversed J shaped age specific mortality pattern. The analysis is restricted to births from January 1983 to the date of the survey. Table 4.1 presents the results of the observed risk of death in each of the six age intervals and the equivalent life table values.

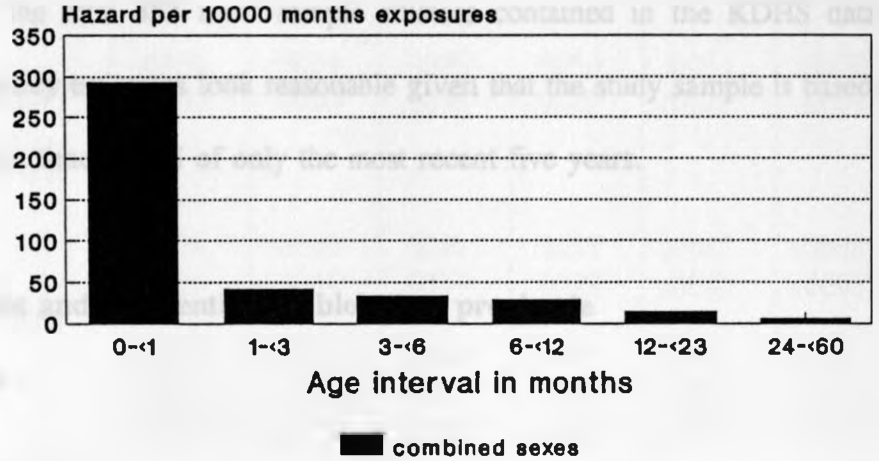
Table 4.1 Empirical risk of death by age interval and the equivalent life table values

Age interval in months	Total expo-sures	Total Deaths	Risk of death	Age x	${}_xS_n$	l_x	${}_xq_0$
0- <1	5662	166	.0293	0	.971	1.000	-
1 -<3	11147	47	.0042	1	.992	.971	.029
3 -<6	16006	52	.0033	3	.994	.963	.037
6 -<12	29551	87	.0029	6	.983	.957	.043
12-<24	49976	70	.0014	12	.983	.940	.060
24-<60	85667	51	.0006	24	.979	.924	.076
60+	-	-	-	60	-	.904	.096

Key:-
${}_xS_n$ Survival probability in age interval x to x+n
l_x Probability of surviving at age x
${}_xq_0$ Probability of dying by age x
Source:- Study sample.

The obtained hazards (instantaneous risk of death) in each of the six age intervals are shown in Figure 4.1, and indicate that the risk is highest in the first age segment (under 1 month), decreases sharply with increase in age and reaches minimum risk in the last age segment (24 to 59 months).The results conform approximately to the expected reversed J shaped age-specific mortality pattern.

Figure 4.1. Hazard plots by age interval (from birth to under age 60 months)



Source Table 4.1

The computed life table values for the probabilities of dying before the specified ages contained in Table 4.1 indicate that the infant mortality rate based on births in the 1983-1989 period is about 60 per thousand live births and that about 96 out of 1000 live births die before attaining age five years. These results do not differ very much from estimates of 59 and 91 per thousand respectively for rural Kenya contained in the 1989 KDHS report.

The estimates given in KDHS report were based on births in the ten year period prior to the survey while the study estimates are based on births in the five year period prior to the survey date. The study estimates are restricted to ever married mothers and to 326 out of the total 353 rural sample clusters contained in the KDHS data set. However, the study estimates look reasonable given that the study sample is based on a shorter reference time period of only the most recent five years.

4.2.2 Estimates and differentials by biological proximate variables

The computed risk of death in the six age intervals by the five biological proximate variables used in this study are presented in Table 4.2 and the equivalent life table probabilities of dying derived from the computed risks are presented in Table 4.3.

Table 4.2. Risk of death in age intervals by biological proximate variables

Variable	Risk of death in the age interval (in months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
	-----	-----	-----	-----	-----	-----
Sex						
Males	.0356	.0034	.0030	.0030	.0011	.0008
Females	.0230	.0050	.0035	.0029	.0017	.0004
Mother's Age at the birth						
<20, 35+	.0374	.0049	.0041	.0032	.0017	.0006
20-34	.0260	.0039	.0029	.0028	.0013	.0006
Birth order						
1	.0465	.0022	.0040	.0035	.0017	.0004
6+	.0291	.0044	.0033	.0029	.0008	.0008
2-5	.0253	.0045	.0030	.0028	.0017	.0005
Birth interval						
<24	.0321	.0048	.0047	.0045	.0016	.0007
24+	.0283	.0040	.0027	.0024	.0013	.0006
Type of birth						
Multiple	.1670	.0272	.0000	.0060	.0010	.0024
Single	.0259	.0037	.0033	.0029	.0014	.0006

Source:- Study sample

Appendix Table 4.1 provides additional information on deaths and total months of exposure in each of the six age segments by these five biological variables and all the other sixteen variables used in this study.

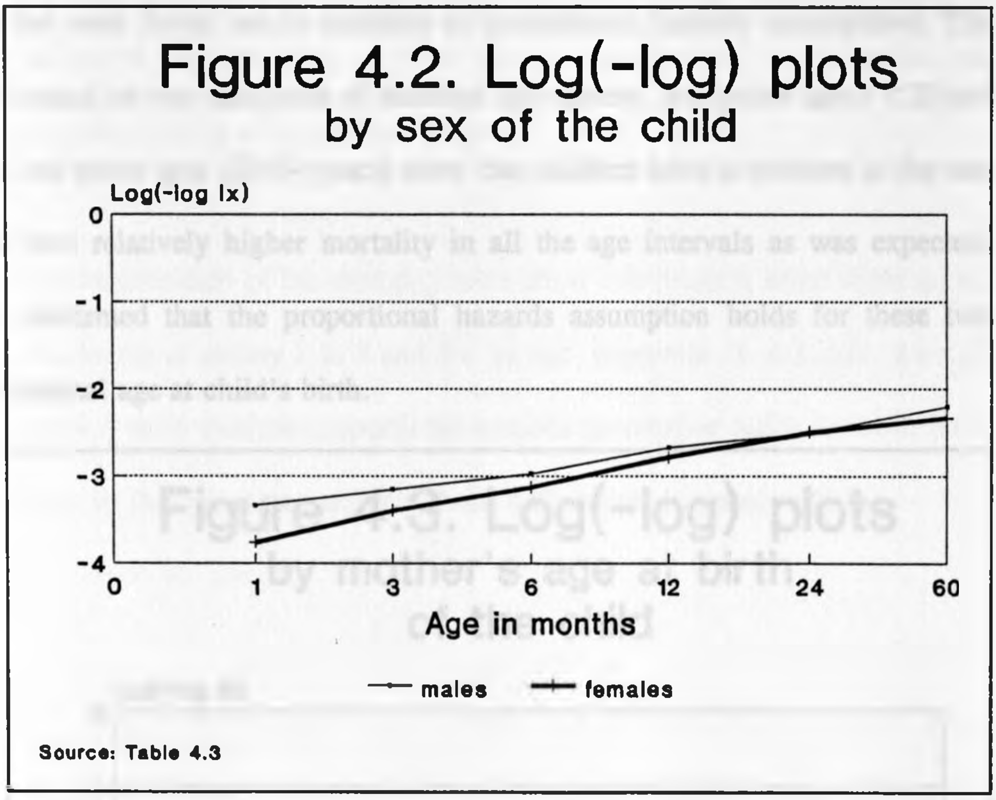
Table 4.3. Equivalent life table probabilities of dying by exact age of childhood by biological proximate variables

Variable	$_xq_0$ values (from birth to exact age x in months)					
	1	3	6	12	24	60
	----	----	----	----	----	----
Sex						
Males	.035	.042	.050	.063	.079	.105
Females	.023	.033	.043	.060	.079	.093
Mother's Age at the birth						
<20, 35+	.037	.046	.058	.076	.095	.116
20-34	.026	.034	.042	.058	.072	.091
Birth order						
1	.045	.049	.060	.079	.098	.112
6+	.029	.038	.047	.064	.073	.097
2-5	.025	.034	.043	.059	.078	.095
Birth interval						
<24 months	.032	.041	.054	.078	.096	.119
24+ months	.028	.036	.044	.058	.073	.091
Type of birth						
Multiple	.154	.199	.199	.227	.236	.298
Single	.025	.032	.042	.058	.074	.093

Source:- Study sample.

4.2.2.1 Sex of child

Although it is quite evident from Table 4.3 that males suffer slightly higher mortality in general as was the expectation of this study, further scrutiny of the age specific hazard rates in Table 4.2 show that excess male mortality does not hold in all the age segments. The data suggest that there is excess female mortality in age segments 1-<3 months, 3-<6 months and in segment 12-<24 months. The log(-log) plots of the life table survival probabilities from birth presented in figure 4.2 also show that the differentials by sex are small and reduce with increase in age. The figure also show that proportional hazards assumption do not hold in general for the two sexes.

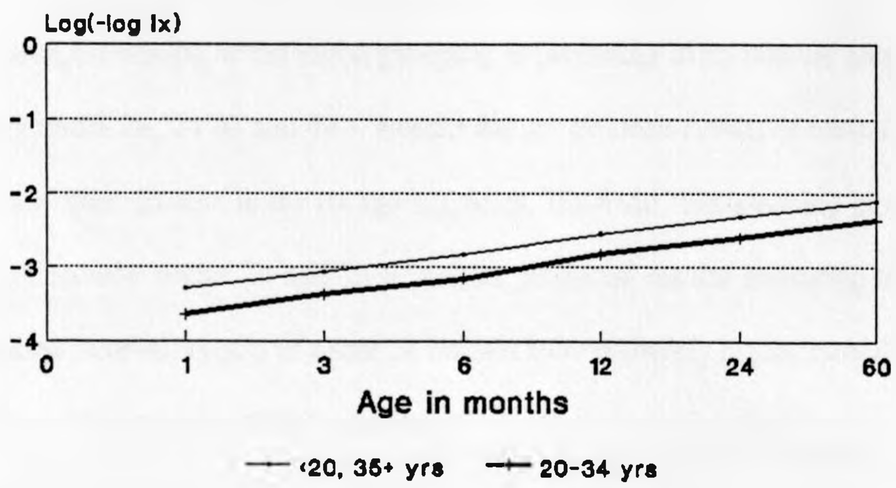


The results on the age pattern of infant and child mortality by sex are consistent with the findings of the other studies cited in the literature. For instance, Rutstein (1983) has indicated on the basis of WFS data that the excess male mortality was not apparent for toddlers or other older children under age five years.

4.2.2.2 Mother's age at child's birth

The three categories of maternal age at birth of the index child used at the preliminary analysis of age-interval-specific hazard rates were under 20, 20 to 34, and 35+ years but were found not to conform to proportional hazards assumptions. The study results based on two categories of maternal age namely, non prime ages (<20 and 35+ years) and prime ages (20-34 years) show that children born to mothers in the non prime ages have relatively higher mortality in all the age intervals as was expected. Figure 4.3 confirmed that the proportional hazards assumption holds for these two groups of maternal age at child's birth.

Figure 4.3. Log(-log) plots by mother's age at birth of the child

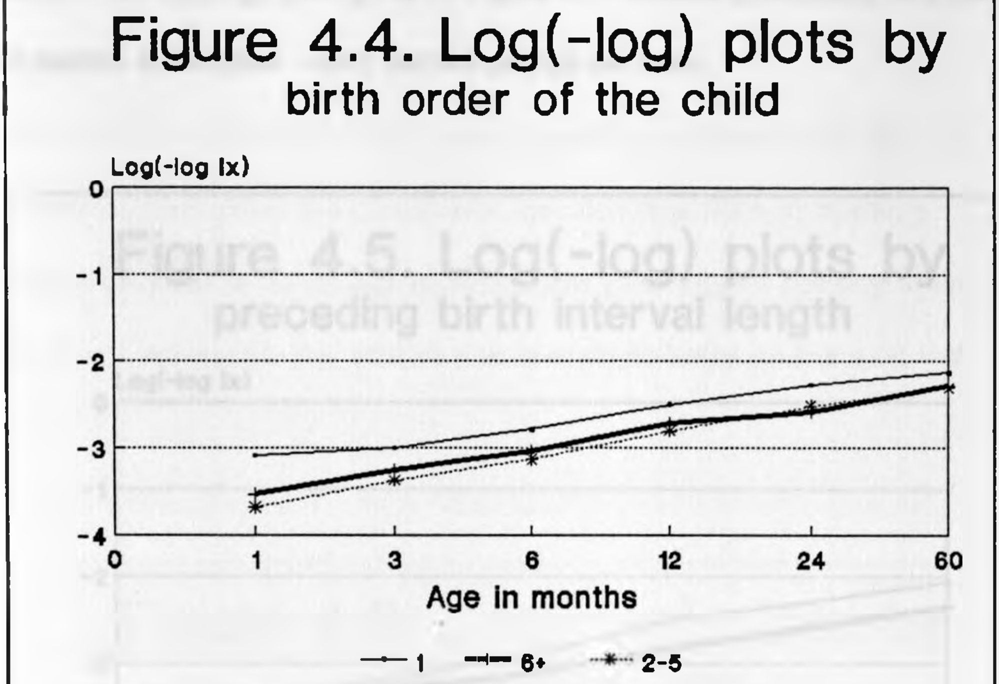


Source: Table 4.3

4.2.2.3 Birth order of child

The results obtained for the age-interval-specific mortality during infancy and childhood by birth order grouped into three (1, 2-5, and 6+) were generally consistent the expected U shaped pattern particularly in the first, third and fourth age segments. The results also indicated that the births of first and 6+ orders have in general excess mortality compared to those of orders two to five.

Detailed examination of the mortality rates show that there is some slight excess of mortality for births of orders 2 to 5 and 6+ in age segments 1-<3 and 24-<60 months. Figure 4.4 show that the proportional hazards assumption holds for birth order 1 versus the rest of the categories and that these differences decrease with age.

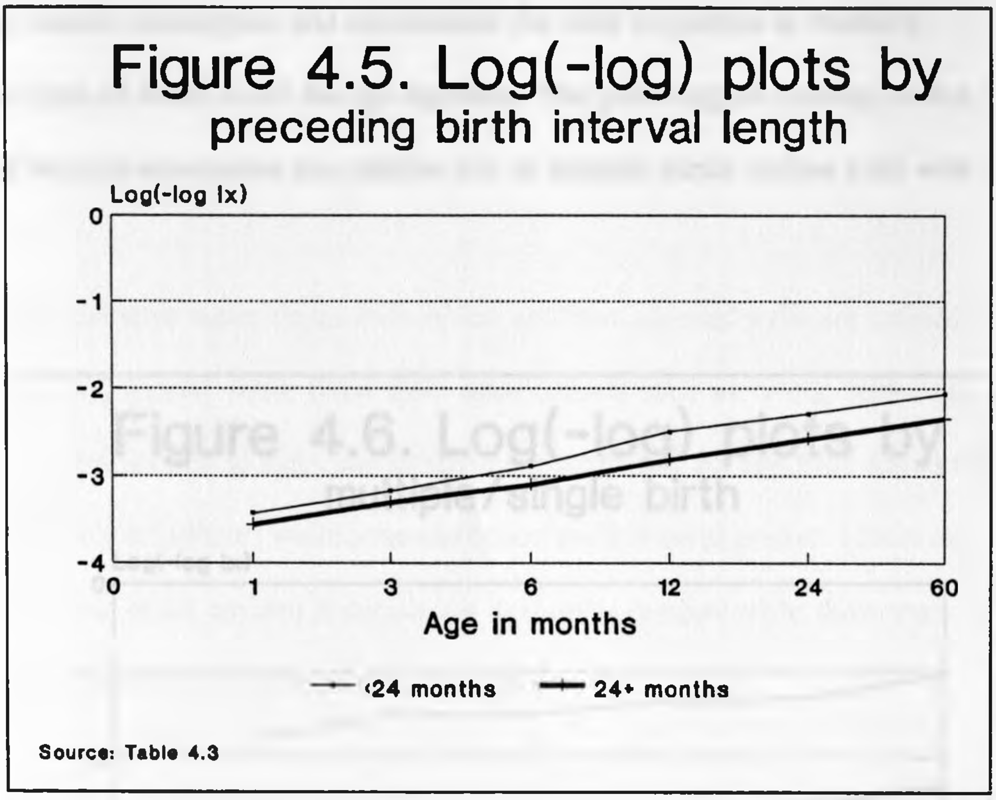


Source: Table 4.3

4.2.2.4 Preceding birth interval

Preliminary analysis results of the initial grouping of preceding birth interval length into three, namely under 24, 24-47 and 48+ months did not produce results of mortality rates that reflect any clear pattern in the six age segments. However, the grouping of the intervals into two, namely under 24 and 24+ months produced results indicating that births with preceding interval lengths of under 24 months have relatively higher mortality compared to those with intervals of 24+ months.

The results of the log(-log) plots given in Figure 4.5 indicate conformity with the proportional hazards assumption when the two groups are used.

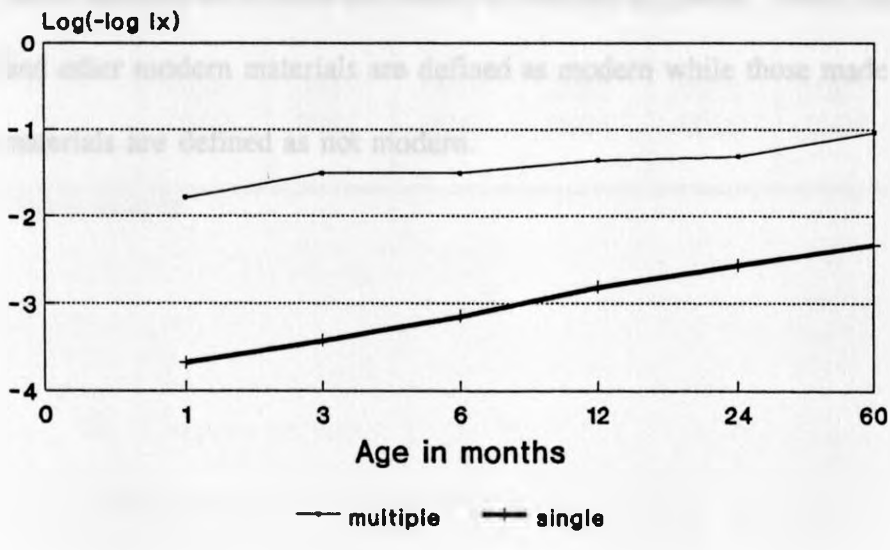


4.2.2.5 Multiple births

It is clearly evident from the results of this study that multiple births have relatively very high mortality rates (about seven times higher) than the singletons, especially in the first two age segments. It should be noted that there was a much smaller number of total months of exposure for the multiple births.

The plots presented in Figure 4.6 also show reasonable conformity with the proportional hazards assumption and demonstrate the wide disparities in mortality between the types of births in all the age segments. The plots suggest contrary to the proportional hazards assumption that relative risk to multiple births decline a bit with age.

Figure 4.6. Log(-log) plots by multiple/single birth



Source: Table 4.3

4.2.3 Estimates and differentials by household environmental proximate variables

As was indicated in Section 2.3.5 in Chapter two, the five variables considered under this category are very important for answering the study questions. Tables 4.4 and 4.5 presents summary results of the computed hazard rates for the six age segments and the probabilities of dying by exact ages of childhood respectively.

Water obtained from water pipes, bore-holes, and from covered wells are defined as clean or less contaminated while those from open sources such as rivers, lakes, open wells and dams are defined as not clean or more contaminated. Pit and flush toilets are defined as better toilet facilities while none and others are defined as poorer. Floors made of cement, tiles and other modern materials are defined as modern while those made of earth and other materials are defined as not modern.

Table 4.4. Risk of death in age intervals by household environmental proximate variables

Variable	Risk of death in the age interval (in months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
	-----	-----	-----	-----	-----	-----
Water quality						
Not clean	.0310	.0042	.0032	.0031	.0015	.0007
Clean	.0248	.0044	.0033	.0024	.0011	.0004
Water Source						
1+ hours	.0324	.0061	.0055	.0027	.0016	.0005
<1 hour	.0305	.0042	.0025	.0034	.0016	.0007
Toilet facility						
None, poor	.0366	.0072	.0047	.0044	.0024	.0006
Better	.0277	.0035	.0029	.0026	.0012	.0006
Floor material						
Not modern	.0321	.0046	.0033	.0033	.0016	.0006
Modern	.0171	.0024	.0030	.0014	.0007	.0005
Siblings of age 5 years or under						
3+	.0148	.0011	.0019	.0022	.0011	.0003
<3	.0392	.0064	.0042	.0034	.0016	.0008

Source:- Study sample

Table 4.5. Equivalent life table probabilities of dying by axact age of childhood by household environmental proximate variables

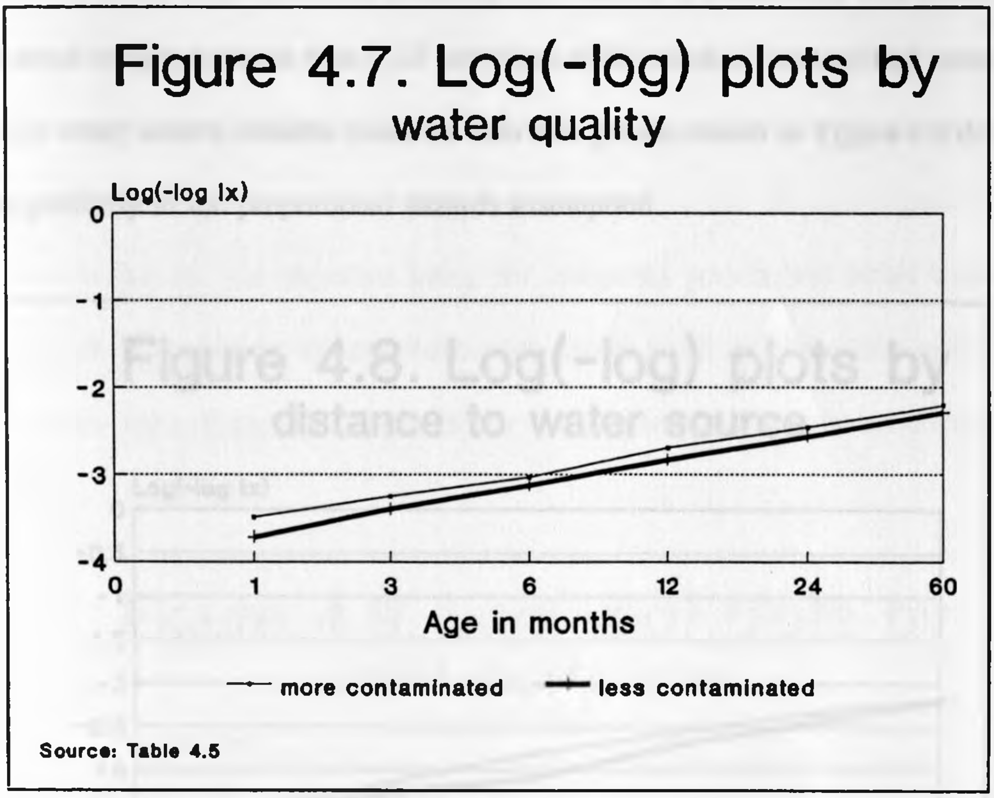
Variable	$_xq_0$ values (from birth to exact age x in months)					
	1	3	6	12	24	60
	----	----	----	-----	----	----
Water quality						
Not clean	.030	.038	.047	.065	.082	.104
Clean	.024	.033	.043	.057	.074	.096
Water Source						
1+ hours	.032	.044	.059	.074	.091	.108
<1 hour	.030	.038	.045	.064	.082	.106
Toilet facility						
None, poor	.036	.050	.063	.097	.112	.131
Better	.027	.034	.042	.057	.070	.090
Floor material						
Not modern	.032	.041	.050	.069	.086	.106
Modern	.017	.022	.031	.039	.047	.064
Siblings of age 5 years or under						
3+	.015	.017	.023	.036	.049	.058
<3	.038	.050	.062	.081	.098	.124

Source:- Study data.

4.2.3.1 Water quality

On the average, the estimates contained in the Table 4.5 show that children in households using more contaminated water have slightly higher mortality than those using clean water. However, the differences are not large in all the age segments and this excess mortality for children in households using more contaminated water is not apparent in ages one to six months.

The log(-log) plots for water quality variable categorized into two given in Figure 4.7 confirm the proportional hazards assumption.

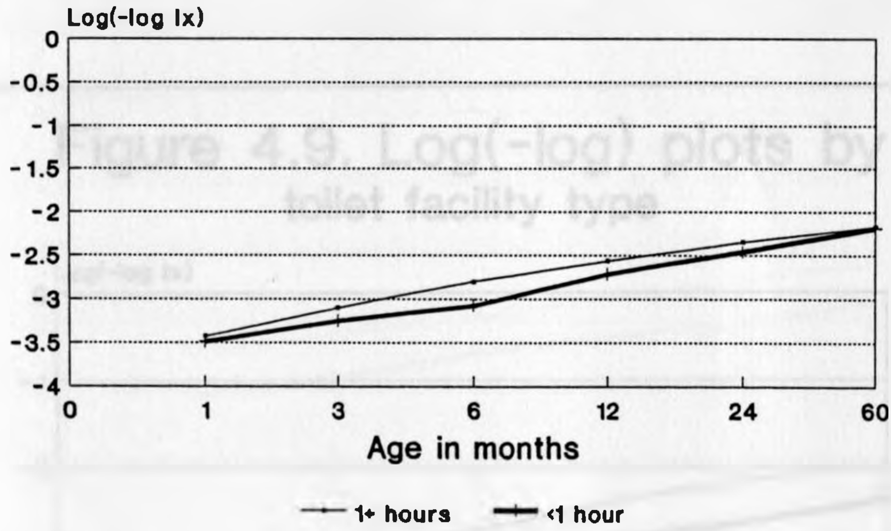


4.2.3.2 Distance (in units of time) to water source

Distance to source of water variable was at the preliminary analysis stage grouped into three, namely under 30, 30-60, and 60+ minutes but had to be collapsed into two groups (<1 hour and 1+ hours) because the first three groupings used did not result in mortality rates that reflect any clear pattern in the six age segments.

The study results show that children born in households with distances to source of water of 1+ hours have higher mortality relative to those in households with distances to water source of under 1 hour. Excess mortality for children in households with under 1 hour was noted in age segments 6 to <12 and 24 to <60 months. The log(-log) plots for distance to water source variable classified into two groups shown in Figure 4.8 do not conform perfectly to the proportional hazards assumption.

Figure 4.8. Log(-log) plots by distance to water source

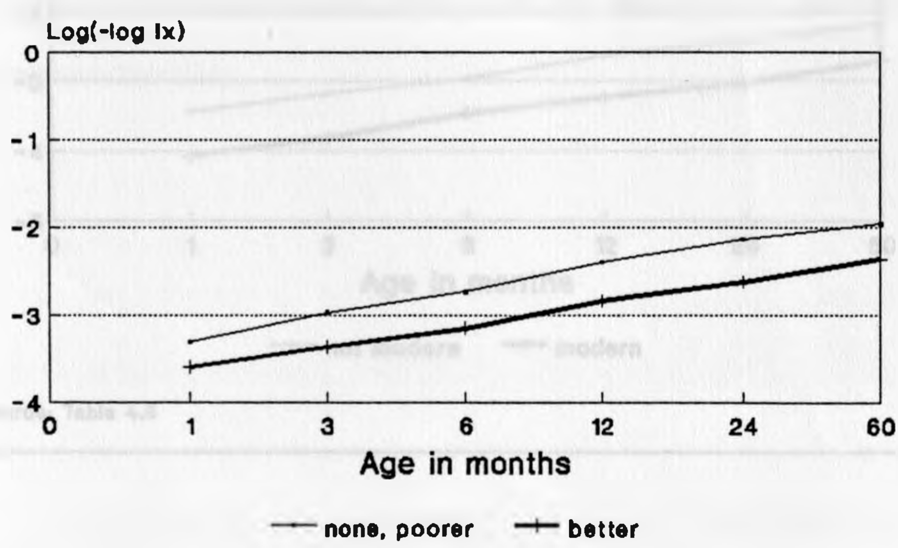


Source: Table 4.5

4.2.3.4 Type of toilet

Type of toilet facility variable was grouped into two: the better (consisting of flush and pit) and the poorer (consisting of none and all the others). At the preliminary stages of analysis, categorizing this variable into three: none; pit and flush; and all others did not result in mortality rates showing any clear pattern in the six age segments. Mortality rates in the six age segments using the categories poorer and better toilet facility types show that children in households with poorer toilet facilities have excess mortality in all the ages. Figure 4.9 confirms that the proportional hazards assumption is not violated.

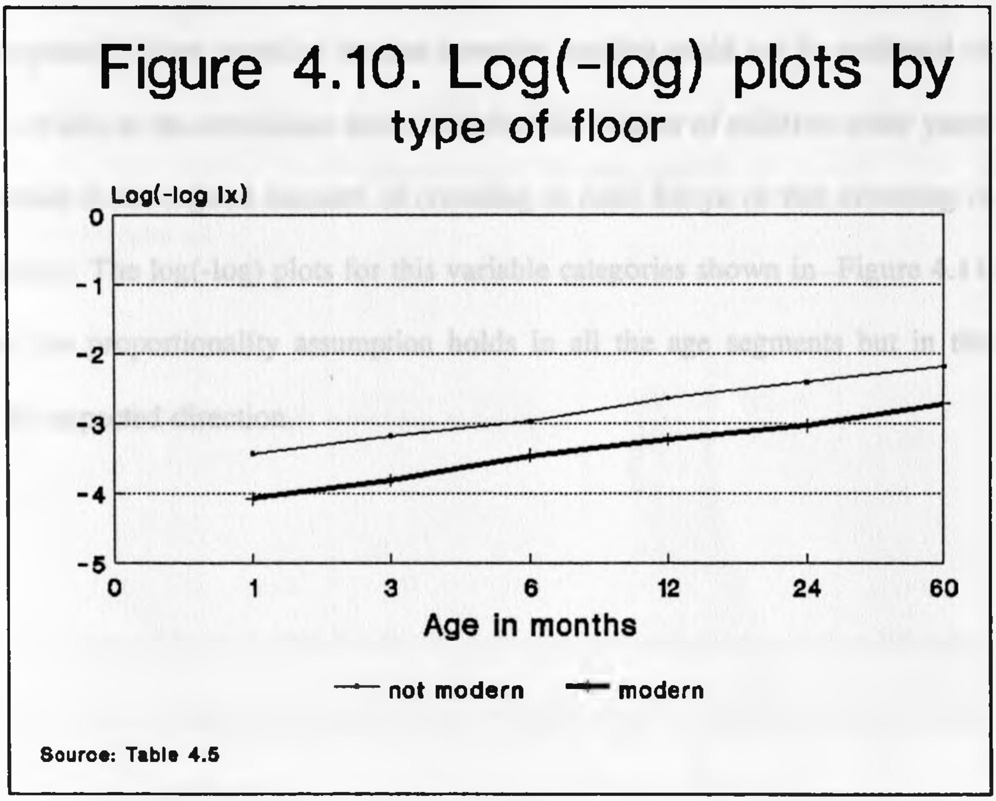
Figure 4.9. Log(-log) plots by toilet facility type



Source: Table 4.5

4.2.3.5 Type of floor

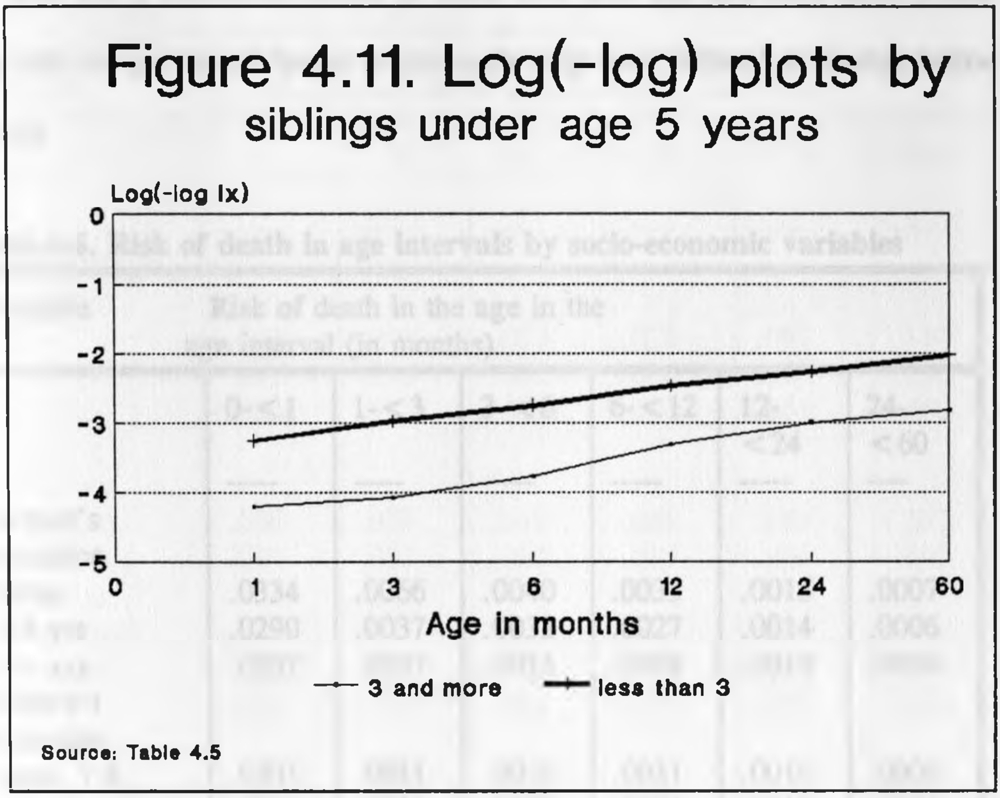
The age-specific mortality rates in the six age segments by the type of floor material indicate that children in households with poorer floor quality have slightly higher mortality in all ages. The categories of floor quality variable conform to the proportional hazards assumption shown in Figure 4.10.



4.2.3.6 Siblings under age 5 years

The number of siblings of age under 5 years in the household is intended to capture the crowding status. The variable produced unexpected results for the six age segments irrespective of the number of siblings chosen. The pattern that emerged was that mortality rates were lower in households with 3 or more other siblings under five than in other households.

The unexpected higher mortality for less crowded families could not be attributed to poor quality of data so the conclusion drawn was that the number of children under years in the household is not a good measure of crowding in rural Kenya or that crowding is not a risk factor. The log(-log) plots for this variable categories shown in Figure 4.11 indicate that the proportionality assumption holds in all the age segments but in the reverse of the expected direction.



4.2.4 Estimates and differentials by socio-economic variables

The estimates of hazard rates for the six age segments and the equivalent life table probabilities of dying by the six socio-economic variables used in this study are presented in Tables 4.6 and 4.7 respectively.

Mothers who listen to radio or in households with a radio were defined as having access to information while those who do not listen or own a radio were defined as having no access to information. Households defined as having above average assets were those with land and a permanent house or those with land and any cash crop. Those households with no permanent house or any cash crop were defined as having below average assets.

Table 4.6. Risk of death in age intervals by socio-economic variables

Variable	Risk of death in the age in the age interval (in months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
	-----	-----	-----	-----	-----	-----
Mother's education						
None	.0334	.0066	.0040	.0035	.0015	.0007
1-8 yrs	.0290	.0037	.0032	.0027	.0014	.0006
9+ yrs	.0207	.0007	.0015	.0026	.0013	.0004
Fathers's education						
none, 1-8	.0301	.0051	.0036	.0031	.0016	.0006
9+ yrs	.0296	.0021	.0025	.0026	.0010	.0006
Access to information						
No access	.0261	.0056	.0045	.0035	.0016	.0006
Some	.0344	.0035	.0026	.0027	.0013	.0006
Household assets						
< average	.0261	.0065	.0044	.0045	.0021	.0008
Average +	.0344	.0027	.0024	.0018	.0011	.0005
Father's occupation						
Non Prof.	.0289	.0045	.0035	.0029	.0015	.0007
Profession	.0334	.0018	.0012	.0033	.0010	.0001
Marital union						
Polygamous	.0396	.0072	.0050	.0044	.0027	.0010
Monogamous	.0258	.0035	.0026	.0025	.0010	.0005

Source: Study sample

Table 4.7. Equivalent life table probabilities of dying by exact age of childhood by socio- economic variables

Variable	$_xq_0$ values (from birth to exact age x in months)					
	1	3	6	12	24	60
	-----	-----	-----	-----	-----	----
Mother's education						
None	.033	.046	.057	.076	.092	.114
1-8 yrs	.029	.036	.045	.060	.076	.096
9+ yrs	.020	.021	.025	.040	.054	.067
Fathers's education						
none, 1-8	.030	.039	.049	.066	.083	.103
9+ yrs	.029	.033	.040	.055	.066	.085
Access to information						
No access	.026	.041	.054	.073	.091	.110
Some	.034	.035	.043	.058	.073	.092
Household assets						
< average	.026	.039	.052	.077	.100	.126
Average +	.034	.039	.046	.056	.069	.085
Father's occupation						
Non Prof.	.028	.037	.047	.063	.079	.100
Profession	.033	.037	.040	.059	.070	.074
Marital union						
Polygamous	.039	.053	.067	.092	.121	.153
Monogamous	.025	.032	.039	.054	.065	.082

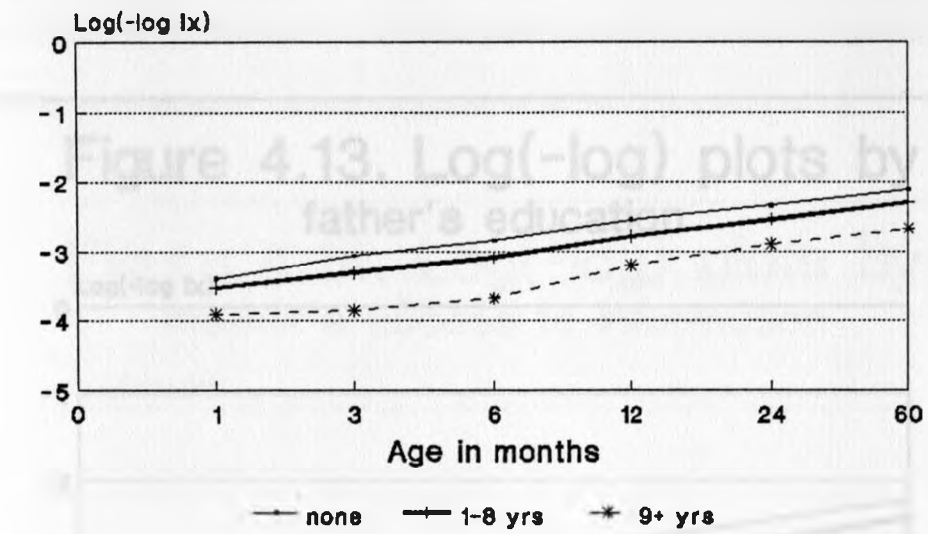
Source:- Study sample.

4.2.4.1 Mother's education

Education of the mother was categorized into three groups and mortality rates in the six age intervals were consistent with the study expectations. The results indicate that infant and child mortality decreases with increase in mothers education and that children whose mothers had nine years and more of schooling have the lowest mortality.

The log(-log) plots for mother's education variable depicted in Figure 4.12 indicate that the proportional hazards assumptions hold approximately, though differentials seem largest at under age 1 year.

Figure 4.12. Log(-log) plots by mother's education



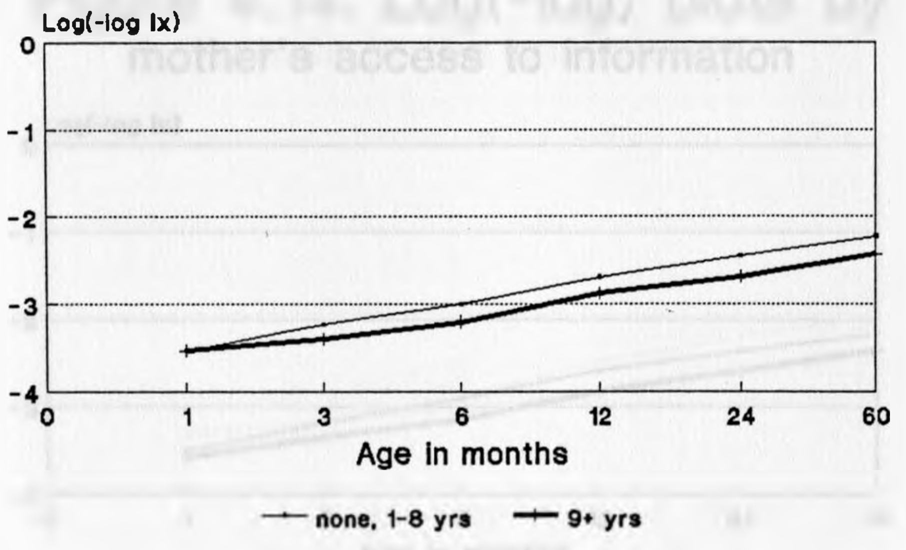
Source: Table 4.7

4.2.4.2 Father's education

Father's education grouped into two (none and 1-8 years as one group and 9+ years as the other) depicted hazard rates indicating decrease in mortality with increase in years of education. Father's education categories similar to the three mother's education groups used in the study did not conform to the expected pattern of mortality rates for the six age segments.

The log(-log) plots for father's education by the two categories presented in Figure 4.13 show that the differentials by father's education groups are not large and that the proportionality assumption hold only beyond the first age segment. Children of fathers with 9+ years of education have slightly lower mortality.

Figure 4.13. Log(-log) plots by father's education

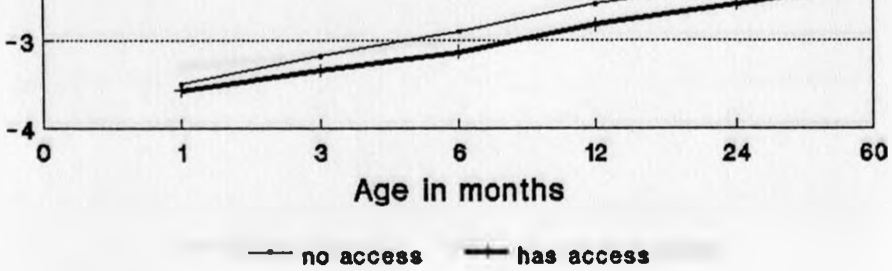


Source: Table 4.7

4.2.4.3 Accessibility to information

Children born to mothers with no access to information are found to have slightly higher mortality in all the six age segments compared to those whose mothers have some access to information. Figure 4.14 show the log(-log) plots by the two groups of mother's accessibility to information. The plots conform approximately to the proportionality assumption of the hazards, but also show that the differentials in mortality rates by these groups of mothers are more apparent after the first month of life.

Figure 4.14. Log(-log) plots by mother's access to information

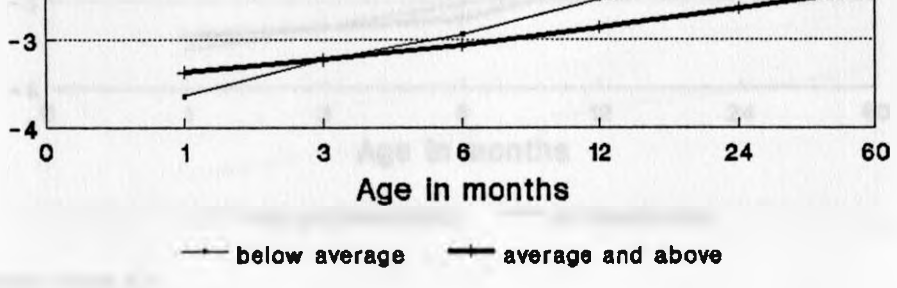


Source: Table 4.7

4.2.4.4 Household assets

Children in households with average and above levels of assets have slightly lower mortality compared to those in households with below average assets in all the age intervals except the first (under 1 month). The log(-log) plots for this variable's categories given in Figure 4.15 show that the variable fails the proportional hazard test assumption.

Figure 4.15. Log(-log) plots by assets in the household

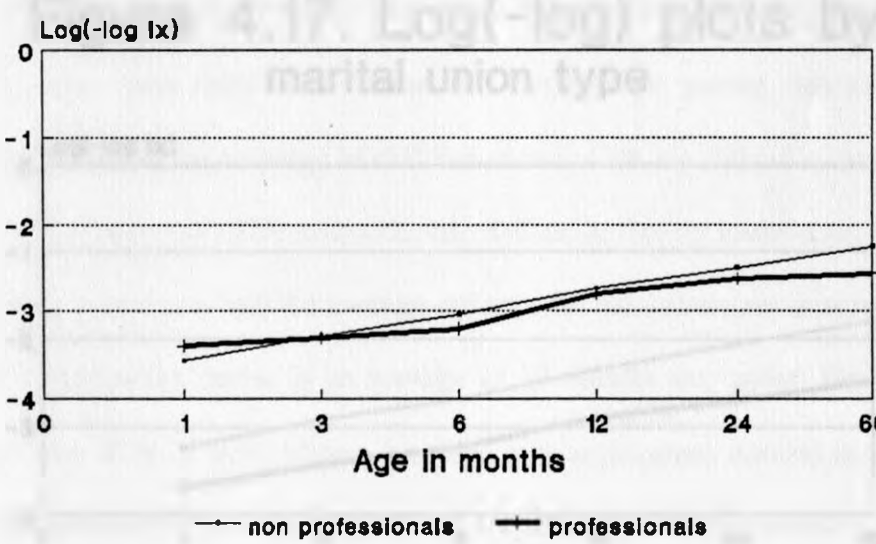


Source: Table 4.7

4.2.4.5 Father's occupation

Father's occupation yielded inconsistent results with respect to mortality rates during infancy and childhood. The final two broad categories (professionals and all others) used also failed to produce a clear mortality pattern since at ages under 1 month and 6 to under 12 months children of the professional cadres depicted unexpected relatively higher mortality compared to the non professionals. The log(-log) plots presented in Figure 4.16 show that the hazards are crossing.

Figure 4.16. Log(-log) plots by father's occupation



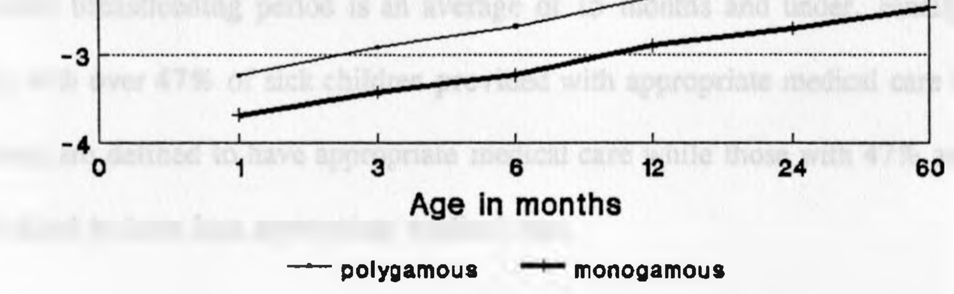
Source: Table 4.7

The inconsistent results regarding the variable father's occupation could be attributed to poor quality of reporting of husband's occupations by the female respondents during the survey.

4.2.4.6 Marital union

Children to polygamous marriages were found to experience higher mortality rates compared with those to monogamous marriages in all the intervals. The plots in Figure 4.17 show that the proportional hazards assumption was not violated and that the differences are large.

Figure 4.17. Log(-log) plots by marital union type



Source: Table 4.7

4.2.5 Estimates and differentials by community environmental variables

The six variables considered under this group of environmental variables were equally very crucial for answering the study research questions. Tables 4.8 and 4.9 presents the estimates of age-interval-specific hazard rates and the equivalent life table probabilities of dying by exact ages in childhood respectively.

Areas with high malaria transmission are defined as endemic while those with low or no malaria transmission are defined as non endemic. Details of the computations of the other four variables are discussed in the sub sections that follow. Communities with over 60% of the children in the normal nutritional category are defined as better nourished while those with 60% and below are defined as poorer nourished. Communities with immunization coverage of children of over 67% are defined as having higher coverage while those with 67% and under are defined as having lower coverage. Longer breastfeeding period is where the average estimate for the community is over 15 months. Shorter breastfeeding period is an average of 15 months and under. Finally, communities with over 47% of sick children provided with appropriate medical care in event of illness are defined to have appropriate medical care while those with 47% and under are defined to have less appropriate medical care.

Table 4.8. Risk of death in age intervals by community environmental variables

Variable	Risk of death in the age interval (in months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
	-----	-----	-----	-----	-----	-----
Malaria						
Endemic	.0391	.0072	.0055	.0052	.0029	.0011
Non	.0217	.0019	.0015	.0012	.0003	.0003
Nutrition status						
Poorer	.0329	.0047	.0037	.0029	.0012	.0006
Better	.0265	.0038	.0029	.0030	.0015	.0006
Immunization						
<67%	.0312	.0046	.0040	.0035	.0017	.0009
67% +	.0270	.0038	.0024	.0022	.0010	.0002
Breastfeeding						
<15months	.0347	.0075	.0044	.0043	.0019	.0006
15+months	.0263	.0021	.0027	.0022	.0016	.0006
Medical care provided						
approp.	.0268	.0038	.0032	.0024	.0015	.0005
not appr.	.0314	.0042	.0033	.0034	.0013	.0007

Source:- Study sample.

Table 4.9. Equivalent life table probabilities of dying by exact age of childhood by community environmental variables

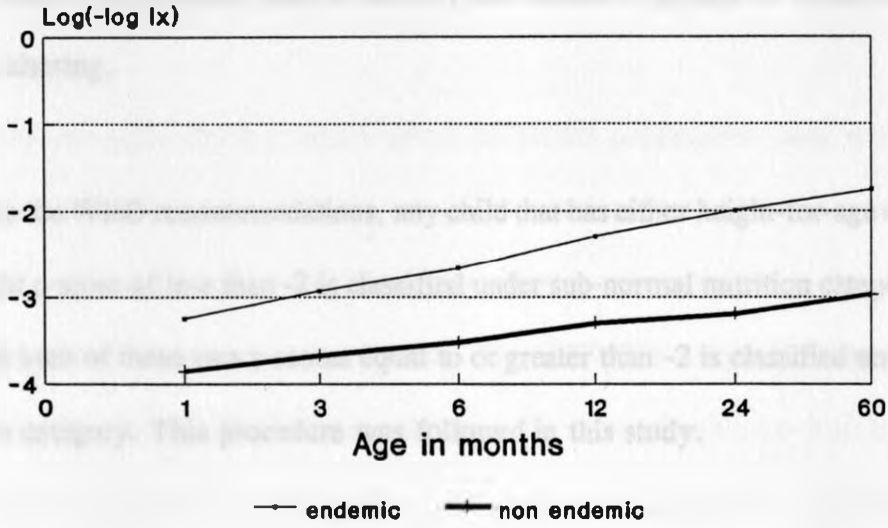
Variable	$_xq_0$ values (from birth to axact age x in months)					
	1	3	6	12	24	60
	----	----	----	----	----	----
Malaria						
Endemic	.038	.052	.067	.096	.127	.157
Not endemic	.021	.025	.029	.036	.040	.050
Nutrition status						
Poorer	.032	.041	.052	.068	.082	.101
Better	.026	.033	.041	.058	.075	.095
Immunization coverage						
<67%	.031	.040	.051	.071	.090	.119
67% +	.027	.034	.041	.053	.065	.073
Breastfeeding duration						
<15 months	.034	.048	.060	.084	.105	.123
15+ months	.026	.030	.038	.051	.064	.084
Medical care provided						
in-approp.	.026	.033	.042	.056	.073	.090
Appropriate	.031	.039	.048	.067	.082	.104

Source:- Study sample.

4.2.5.1 Malaria

It is apparent from the study results that children in communities where malaria is endemic have on the average much higher mortality rates in all the age intervals compared to those in communities where malaria is non endemic. The life table probabilities of dying show that the differences in mortality between these malarial groups increase with age and become as large as a factor of three by age 60 months. The two categories of the malarial variable also conformed approximately to the proportional hazards assumption as shown by plots in Figure 4.18.

Figure 4.18. Log(-log) plots by malaria endemicity



Source: Table 4.9

4.2.5.2 Nutrition status

The World Health Organization recommended the use of anthropometric indices such as weight-for-height, height-for-age, and weight-for-age calculated for individuals up to age 18 years as a standard procedure for determining nutritional status . These anthropometric information for individuals or groups of children in specified ages by sex can be compared with those for the WHO International Growth Reference. The comparison of anthropometric measures for children in the population with those in the International Reference population can be presented using centiles, standard deviations (z-scores) or percent-of-medium values. For instance, the cut-off point of below -2 standard deviations from the International Reference population of any of the anthropometric indices is generally used to identify individuals or groups of children at risk of growth faltering.

According to the WHO recommendations, any child that has either height-for-age and weight-for-height z-score of less than -2 is classified under sub-normal nutrition category while those with both of these two z-scores equal to or greater than -2 is classified under normal nutrition category. This procedure was followed in this study.

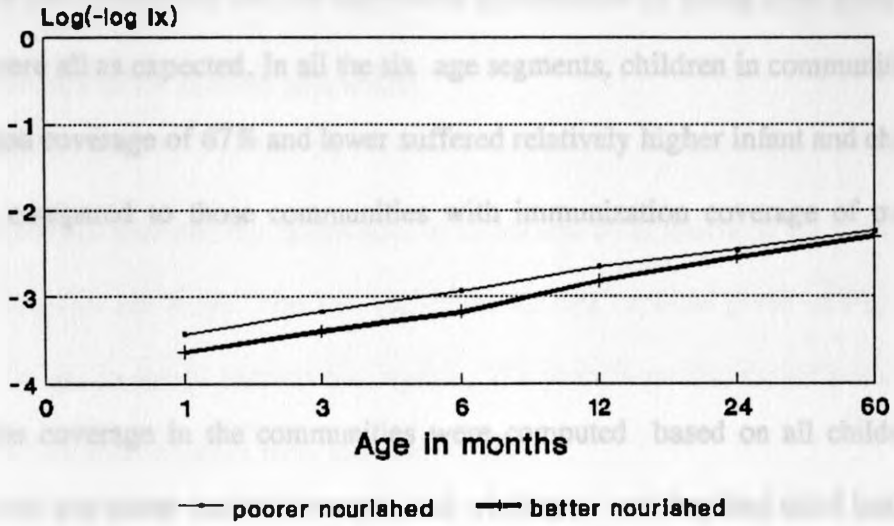
The data file containing the nutrition data used in this study obtained from the Central Bureau of Statistics in Nairobi, Kenya had values of the required z-scores already computed and stored as part of the data for each of the individual child covered in the survey. In order to be sure that these already computed z-score values contained in the data set were correct, a five percent random sample was drawn and new z-score values computed from the basic raw data on heights and weights by age. The computer software programme used was ANTHRO version 1.01 released by the Nutrition Unit of the World Health Organization in Geneva, Switzerland on December 10, 1990.

The newly computed z-score values using ANTHRO programme were nearly exactly the same with the z-score values contained in the data file. The ANTHRO z-score values for the height-for-age were exactly the same with the ones contained in the data set when rounded to the nearest one decimal place. The ANTHRO weight for height z-scores were also fairly close to the ones contained in the data set with the maximum difference of only 0.3. Overall, none of the sampled cases belonged to a different classification category from the earlier assigned based on the ANTHRO results. It was therefore evident from the five percent sample that the z-scores contained in the data file were valid and for that reason were adopted for use in this study.

In the 326 communities considered, the proportion of all children found to be in the normal nutrition category was estimated at 62 percent. The initial categorization criteria used to group the communities with respect to nutritional status of children was simply the subdivision of all the 326 clusters into three according to the cluster estimate of the proportion in the normal category. This gave results that could be classified as the lower, middle and the upper thirds. No clear pattern of age-interval-specific mortality rates emerged when these three groups were used so another criteria, of taking the lower 40 percent as the worse-off group and the upper 60 percent as the better-off group, was adopted. This categorization produced age-interval-specific mortality rates that had a clear pattern. The cut-off point for the lower 40% were those communities having 60 percent and under of the children in normal nutrition category.

Although the results obtained using this later grouping criterion indicate that children in communities with poorer nutrition status have relatively higher infant and child mortality rates in general, further scrutiny of the age-interval hazard rates suggest that the reverse is the case as from age 5 months. The possibility of error source from inaccurate measurements of weights and heights was not possible to evaluate precisely since the ANTHRO programme used did not flag any of the entries, confirming that the measurements entered were within the acceptable range of tolerance with respect to the measurement errors in weights and heights for each child. The log(-log) plots for this variable categories given in Figure 4.19 indicate that the proportional hazards assumption was not seriously violated, and that the differentials by the two nutritional status categories are not large especially after the first year of life.

Figure 4.19. Log (-log) plots by nutrition status of children



Source: Table 4.9

4.2.5.3 Immunization coverage

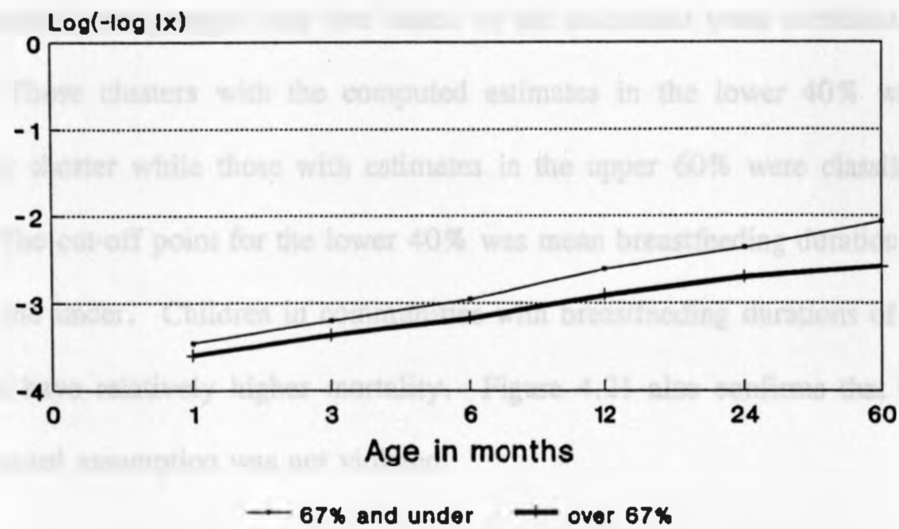
The results of this study with respect to the mortality rates by immunization status of the children in the community and the equivalent probabilities of dying from birth to age 60 months were all as expected. In all the six age segments, children in communities with immunization coverage of 67% and lower suffered relatively higher infant and child mortality when compared to those communities with immunization coverage of over 67%.

Immunization coverage in the communities were computed based on all children (those born to ever and never married women, and whether or not they had child health cards at the time of the KDHS survey). The immunization schedule (KDHS, 1989: p.63) which has been used by the Ministry of Health in implementing the Kenya Expanded Programme of Immunization (KEPI) was used to determine immunization status for the children found to have the health cards containing information on immunizations. Information obtained on immunization status through maternal recall for those children without health cards was incorporated in the calculation of immunization coverage by using the method proposed by Boerma and others (1990: p.7).

The study results obtained using the Boerma at al. (1990) method are quite plausible. The mean completeness of immunization coverage was found to be 61 per cent. The basis used in the classification of the clusters by levels of immunization coverage was similar to the one used for the nutritional status discussed already. Clusters falling in the lower 40 percent in the distribution were considered as the poorer immunization group while those in the upper 60 percent were considered as the better-off immunization group. The lower 40 percent category consisted of those communities with immunization coverage of 67 percent and under.

The results also show that the differences in infant and child mortality by the two immunization categories are large. The log(-log) plots for this variable given in Figure 4.20 conform to the proportional hazards assumption. The plots show that the differences in mortality rates increases slightly with increase in age.

Figure 4.20. Log(-log) plots by immunization coverage



Source: Table 4.9

4.2.5.4 Breastfeeding duration

Mean breastfeeding durations for the communities were computed using direct estimation, utilizing the reported durations of the breastfeeding in the last closed birth intervals in the clusters for both the ever and never married women. A much superior method would have been the use of the incidence-prevalence approach, but this method was not feasible for this analysis due to the small sample sizes in the clusters. Although the estimated mean length of breastfeeding for the study sample is lower (15.5 months) compared with the 19.5 months estimated for rural Kenya using indirect method (KDHS, 1989), the study results were considered reasonable because last closed intervals tend to be short.

The clusters were grouped into two based on the calculated mean durations of breastfeeding. Those clusters with the computed estimates in the lower 40% were classified under shorter while those with estimates in the upper 60% were classified under longer. The cut-off point for the lower 40% was mean breastfeeding duration of 15 months or and under. Children in communities with breastfeeding durations of 15 months or less have relatively higher mortality. Figure 4.21 also confirms that the proportional hazard assumption was not violated.

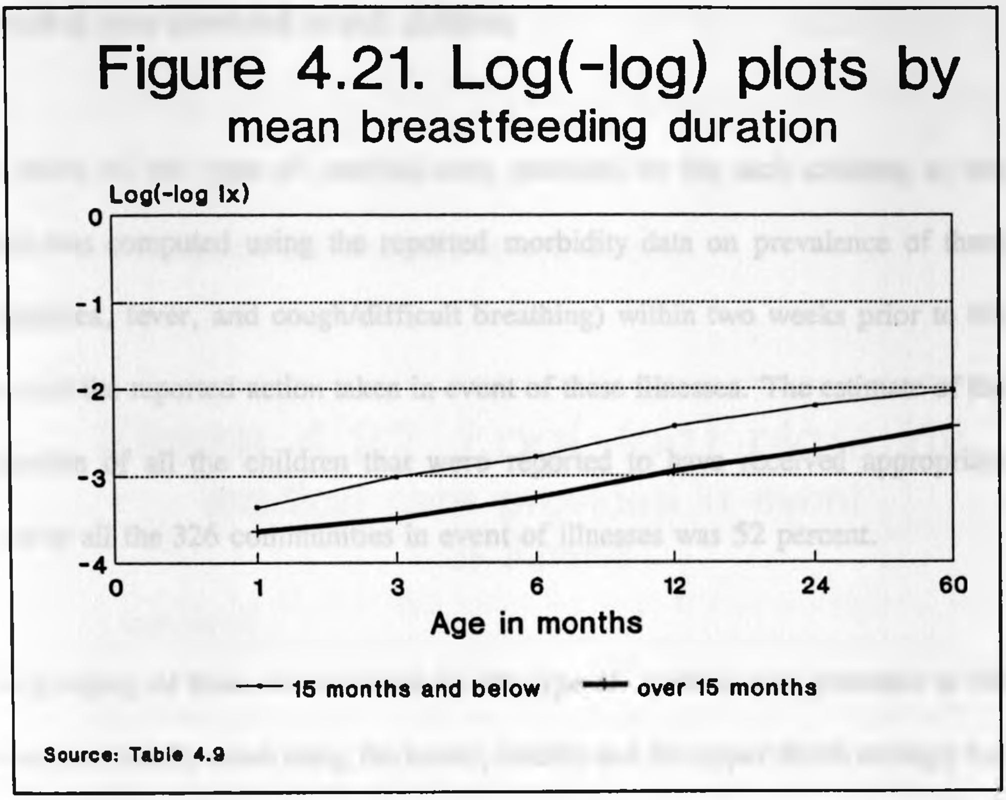


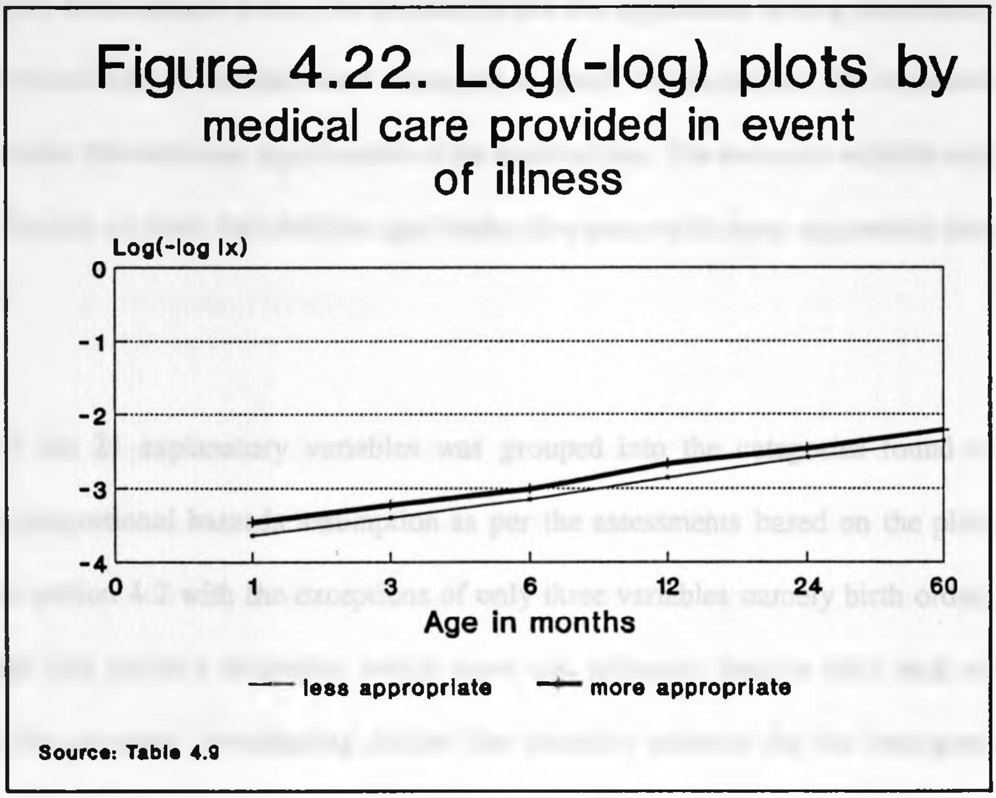
Figure 4.21. Log(-log) plots by
mean breastfeeding duration
Log(-log lx)
0
-1
-2
-3
-4
0
1
3
6
12
24
60
Age in months
15 months and below
over 15 months
Source: Table 4.9

4.2.5.5 Medical care provided to sick children

An index of the type of medical care provided to the sick children in the communities was computed using the reported morbidity data on prevalence of three illnesses (diarrhea, fever, and cough/difficult breathing) within two weeks prior to the survey date and the reported action taken in event of these illnesses. The estimate of the mean proportion of all the children that were reported to have received appropriate medical care in all the 326 communities in event of illnesses was 52 percent.

The grouping of these communities by the type of medical care provided to the sick children was initially done using the lower, middle and the upper thirds strategy but this did not result in any clear pattern with respect to mortality rates. The use of the lower 40 percent and the upper 60 percent as the less appropriate and the more appropriate groups respectively yielded a clear pattern, but also unexpected result: in all the age intervals, children in communities with less appropriate medical care (where 47 percent or below of the sick children were provided with appropriate medical care) have relatively lower mortality compared to those in communities more appropriate medical care. It is also not clear whether some of the reported illnesses diagonized by the mothers were correctly diagonized and warranted medical attention.

The study results on the type of medical care based on the two groups conformed to the proportionality assumption of the hazards as depicted in Figure 4.23. Further exploration of this variable was done to determine what cut-off point would reverse its direction and it was found to be only at the 100 percent implying where all the sick children were given appropriate medical treatment. This was not preferred since only 5 per cent of all the communities fell in the appropriate category.



4.3 UNIVARIATE ANALYSIS OF THE FACTORS ASSOCIATED WITH RISK OF DEATH FOR CHILDREN AGED UNDER FIVE YEARS.

4.3.1 The univariate models run

In Chapter three section 3.4.3, the estimation and the hypotheses testing procedures using proportional hazards models were discussed in detail. In this section, the objective was to determine the statistical significance of the associations. The outcome variable was defined as the risk of death for children aged under five years with ages segmented into six groups.

Each of the 21 explanatory variables was grouped into the categories found to conform to proportional hazards assumption as per the assessments based on the plots presented in section 4.2 with the exceptions of only three variables namely birth order, mother's age and father's education which were not collapsed despite their lack of conformity for purposes investigating further the mortality patterns for the biological variables and to facilitate comparison of the magnitude of associations between risk of death by mother's and by father's education in univariate context.

Apart from the intention of utilizing the univariate results to select the important variables for inclusion in the final analysis model, the results were also expected to provide answers to the first part of the study research question [stated in Chapter one section 1.2.2] which was to determine whether the household and community environmental factors have significant influence on the risk of death for the children aged under five years in rural Kenya.

A total of 21 univariate models were run (one for each variable, not counting the age interval variable serving as a control). In each model, the category of the variable found to have the highest risk was used as the reference group except for the medical care variable. Appendix table 4.1 also provides a summary of the total months of exposure for each of these variables classified by the six age segments and their appropriate groups as specified in the univariate modeling.

In order to test the statistical significance of these associations, the statistical null hypothesis formulated for each of the univariate models was that there was no significant association between the risk of death for the children in the six age intervals and each of the variable categories. Two-tailed t-statistics were used to conduct the statistical test of significance at various confidence levels.

4.3.2 Results of the univariate analysis

The results of the univariate analysis are summarized in Table 4.10. Values of the scaled deviance and degrees of freedom for each of the 21 univariate models run are also provided in the table.

Table 4.10 Results of the univariate models with risk of death for children aged under five years in the six age segments as the outcome variable

Variable	Beta coefficient	Standard error	Scaled deviance	Degrees of freedom
Sex			17.323	5
Females	-0.095	0.092		
Males (Ref)				
Mother's age at the birth			3.472	10
35+ years	-0.388**	0.156		
20-34 years	-0.456***	0.119		
<20 years (Ref)				
Birth order			19.237	10
6+	-0.219	0.141		
2-5	-0.230*	0.135		
1 (Ref)				
Birth interval			4.361	5
24+ months	-0.292***	0.098		
<24 months (Ref)				
Type of birth			22.637	5
Single	-1.356***	0.169		
Multiple (Ref)				
Water quality			2.931	5
Less contaminated	-0.227**	0.111		
More contaminated (Ref)				
Water source distance			8.729	5
<1 hour	-0.078	0.110		
1+ hours (Ref)				
Toilet facility			3.787	5
Pit, flush	-0.430***	0.105		
none, poorer (Ref)				
Floor quality			3.034	5
Modern material	-0.567***	0.143		
Earth, others (Ref)				
Siblings 5 years or under			11.754	5
<3	0.824***	0.110		
3+ (Ref)				

Table 4.10 (cont.)

Mother's education			8.054	10
1-8 years	-0.194**	0.098		
9+ years	-0.552***	0.173		
None (Ref)				
Father's education			16.894	10
1-8 years	-0.231*	0.122		
9+ years	-0.392**	0.139		
None (Ref)				
Mother's access to information			3.792	5
Has access	-0.204**	0.094		
No access (Ref)				
Household assets			23.982	5
Average and above	-0.176*	0.097		
Below average (Ref)				
Father's occupation			10.039	5
Professional	-0.231	0.167		
Non Professional (Ref)				
Marital union			3.452	5
Monogamous	-0.624***	0.101		
Polygamous (Ref)				
------------------------	------------	----------	---------	-----------
Malaria endemicity			24.551	5
Non endemic	-0.152***	0.101		
Endemic (Ref)				
Nutrition status			3.270	5
Better	-0.084	0.092		
Poorer (Ref)				
Immunization coverage			11.646	5
67% +	-0.410***	0.097		
<67% (Ref)				
Breastfeeding duration			12.411	5
15+ months	-0.463***	0.092		
<15 months (Ref)				
Medical care provided			5.976	5
More appropriate	0.222***	0.101		
Less appropriate (Ref)				

*** Significant at 99% level using two-tailed t-test
** Significant at 95% level using two-tailed t-test
* Significant at 90% level using two-tailed t-test

On the basis of the information contained in Table 4.10 the following conclusions can be drawn regarding the directions of the associations and the statistical hypotheses that were tested:-

(i) The directions of association between each of these 21 variables and the outcome variable were all as expected except for only two namely the number of siblings aged under 5 years in the household and type of medical care provided to the sick children in the community.

(ii) Age at maternity, birth order, birth interval and type of birth (multiple/single) are statistically significant biological proximate factors associated with the risk of death for children aged under five years in rural Kenya. Sex of the child is not a significant factor though the females have a lower risk compared to the male births. Using children born to mothers aged under 20 years as the reference category, those born by mothers in their prime reproductive ages (20-34 years) have a significantly lower risk of death at 99% confidence level while those born by mothers at ages 35+ years have significantly lower risk of death at 95% confidence level. Using birth order 1 as the reference category, only births of orders 2-5 have a significantly lower risk of death at 90% confidence level, while those of birth orders 6+ have insignificantly lower risk of death.

(iii) Modern type of toilet facility and better quality of housing floor are statistically significant household level environmental factors associated with lower risk of death for children aged under five years at 99% confidence level. Less contaminated water is associated with lower mortality risk at 95% confidence level, while shorter distance to water source is not a significant factor although relatively shorter times to water source are associated to lower risk of death. Number of siblings under 5 years not exceeding 3, though statistically significantly associated with risk of death at 99% confidence level, it is not measuring the intended effect due to its positive sign.

(iv) Higher maternal and father's education, access to information, possession of average and above household assets and monogamous type of marital union are statistically significant socio-economic factors associated with lower risk of death for the under fives in rural Kenya at 90% confidence level and above. Father's occupation variable is a statistically insignificant socio-economic factor although children whose father's occupation category is professional have relatively lower risk of death.

(v) Malaria non endemic, higher immunization coverage and longer mean durations of breastfeeding are statistically significant community level environmental factors associated with lower risk of death for infants and children aged under 5 years at 99% confidence level in rural Kenya. The nutrition factor, although statistically insignificant, suggest that children in communities with relatively better nutrition status have lower risk of death. Children in communities where appropriate medical care was provided had unexpected and statistically significant at 95% elevated risk of death.

The results from the univariate analysis enable us to conclude that indeed both the household and community levels environmental factors are significantly associated with the risk of death for children under the age of five years in rural Kenya. At the household level sanitation, quality of housing floor, and quality of water are the important factors. At the community level malaria, immunization coverage, and mean breastfeeding duration are the important factors. The performance of these variables in the multivariate context are examined in the next chapter.

CHAPTER 5

THE IMPACT OF ENVIRONMENTAL AND OTHER FACTORS ON INFANT AND CHILD MORTALITY IN RURAL KENYA

5.1 INTRODUCTION

In Chapter three section 3.5, a detailed account of the rationale and strategy adopted for fitting the sub-models and the full analysis model was presented. This chapter focuses on the results and interpretations of these models. The results of the three multivariate sub-models used to screen the proximate determinants, the socio-economic variables and the community level environmental variables are presented and discussed in section 5.2. The results of the final multivariate models fitted to determine the impact of environmental and other variables on infant and child mortality are presented and discussed fully in section 5.3.

5.2 RESULTS AND DISCUSSION OF MULTIVARIATE SUB-MODELS FOR SCREENING THE VARIABLES

5.2.1 Sub-model for screening the proximate variables

A total of eight variables not counting age interval were initially included in the multivariate screening sub-model as independent explanatory variables with the risk of death. The four biological proximate variables from the univariate models that were found to be statistically significant at 90% level of confidence or higher were included in the multivariate sub-model. These variables were maternal age, preceding birth interval, type of birth, and birth order. In addition, sex of child was included to determine its role in the mechanism, if any, despite its insignificance at 90% level of confidence.

The other three proximate variables included in the screening sub-model were the household-level environmental variables from the univariate models that were found to be statistically significant at 90% level of confidence or higher and also with the expected direction of influence. These three variables were water quality, type of toilet facility, and type of floor material. Table 5.1 presents the results of the screening process of these eight proximate variables with their categories collapsed appropriately to conform to the proportional hazards assumption.

Table 5.1. Results of the screening sub-model for the proximate variables in multivariate analysis

Variable excluded from the model	Model		Changes from full screening model	
	Deviance	D.F	Deviance	D.F
None (full)	565.01	746	-	-
Sex	566.42	747	1.41	1
Maternal age	569.66	747	4.63*	1
Birth order	570.86	747	5.85**	1
Birth interval	580.55	747	15.54***	1
Type of birth	612.26	747	47.25***	1
Water quality	567.56	747	2.55	1
Toilet facility	576.92	747	11.91***	1
Floor material	576.72	747	11.71***	1

Key:-
*** Significant at 99% level using chi-square test.
** Significant at 95% level using chi-square test.
* Significant at 90% level using chi-square test.
D.F Degrees of freedom.

Source:- Study data.

The results of the multivariate sub-model for screening the proximate variables indicate that:-

(i) all the proximate variables included in the sub-model except sex of child and water quality are significant proximate determinants of the risk of infant and child mortality in the six age segments. Maternal age is significant at 90% confidence level, birth order at 95% confidence level and the other two biological variables (type of birth and preceding birth interval) are significant at 99% confidence level.

(ii) type of floor material is mainly responsible for the insignificance of the variable water quality in the multivariate sub-model since it was found to capture much of the effects of water quality to the extent that without it, water quality becomes significant at 95% confidence level.

(iii) the birth order variable is capturing some of the effects of maternal age in the multivariate sub-model such that without it, maternal age becomes significant at 99% confidence level.

(iv) the variable sex of child is insignificant and its effect is not being captured by any of the variables included in the multivariate sub-model.

(v) the direction of influence of all the proximate variables included in the screening sub-model are in the expected direction such that the signs on the coefficients of the better-off group (entered in the analysis as the non-reference group) are all negative implying having relatively lower risk of death.

Further investigation of the relationships between the variables in the multivariate sub-model was done using cross tabulation procedure focusing on the variables found to cause some changes in direction and magnitude of the coefficients of the other variables in the screening process. Only two pairs of variables were found to be significantly related at 95% level of confidence or higher using a chi-square test. Type of birth and quality of floor material were found to be significantly related whereby multiple births occurred mainly in households with poorer floor material. Since there exists no readily available theory to explain this relationship, it could be concluded that this was only due to chance. The other pair of variables found to be significantly related were birth interval and birth order whereby a large proportion of births of order 2 to 5 had also shorter preceding birth intervals. This relationship can be explained by the existence of relatively high fertility in rural Kenya attained partly by short inter-birth intervals.

On the basis of these results, the variables sex of child and quality of water are not considered for inclusion in the full and final multivariate models.

5.2.2 Sub-model for screening the socio-economic variables

In the socio-economic multivariate sub-model, a total of four variables not counting age interval were used as the full screening model. The four variables included were those found to be statistically significant at 90% confidence level or higher in the univariate models presented in section 4.3.2, namely mother's education, father's education, information accessibility and type of marital union. The household assets variable was excluded from the multivariate sub-model although it had been found to be significant at 95% confidence level in the univariate analysis due to the observation that it was distorting seriously the pattern of the age specific hazards in the six age segments. Table 5.2 presents the results of the screening process for the socio-economic variables included in the model.

Table 5.2. Results of the screening sub-model for socio -economic variables in multivariate analysis

Variable excluded from the model	Model		Changes from full screening model	
	Deviance	D.F	Deviance	D.F
None	128.43	133	-	-
Mother's educ	131.52	135	3.09	2
Father's educ	128.94	134	0.51	1
Information	129.36	134	0.93	1
Marital union	158.34	134	29.90***	1

Key:-
*** Significant at 99% level using chi-square test.
** Significant at 95% level using chi-square test.
* Significant at 90% level using chi-square test.
D.F Degrees of freedom.

Source:- Study data.

The results of the socio-economic multivariate sub-model indicate that:-

(i) only the variable type of marital union is significant at 99% confidence level in the model; the other three variables are not significant even at the 90% level.

(ii) some effects of maternal education are being captured by the other three socio-economic variables in the model such that excluding any one of them results in significance of maternal education at 95% confidence level.

(iii) although some of the effects of father's education and accessibility to information were being captured by maternal education, their effects remained insignificant even when maternal education was removed from the model.

(iv) the direction of influence of each of the four socio-economic variables included in the sub-model are in line with the expectation of the study whereby the coefficients of the better-off groups (non-reference groups) all have negative signs implying having relatively lower risk of death.

Further analysis of the cross tabulations for the variables found to affect the magnitude of the coefficients of each other in the screening process resulted into having no pair being significantly related in the model at 95% confidence level using a chi-square test. On the basis of the results of this sub-model, only two variables, namely type of marital union and maternal education are considered for inclusion in the final model.

5.2.3 Sub-model for screening the community level environmental variables

Three community level environmental variables, namely malaria, immunization coverage, and breastfeeding duration were found to be significant at 99% level of confidence and also with the expected direction from the univariate analysis and hence were included in the screening sub-model. The variable type of medical care was found to be significant at 95% confidence level but could not be considered for inclusion in the sub-model due to its unexpected direction of association in the univariate analysis. The variable nutrition status was included in the screening sub-model despite not being statistically significant at 90% level of confidence due to its importance to the study. The four community level environmental variables not counting age interval variable were therefore used in the multivariate screening sub-model as the independent explanatory variables. Table 5.3 presents the results of the screening process for these community-level variables.

Table 5.3. Results of the screening sub-model for the community level environmental variables in the multivariate analysis.

Variable excluded from the model	Model		Changes from full screening model	
	Deviance	D.F	Deviance	D.F
None (full)	131.68	86	-	-
Malaria	246.59	87	114.91***	1
Nutrition	131.69	87	0.01	1
Immunization	133.79	87	2.11	1
Breastfeeding	146.59	87	14.91***	1

Key:-
*** Significant at 99% level using chi-square test.
** Significant at 95% level using chi-square test.
* Significant at 90% level using chi-square test.
D.F Degrees of freedom.

Source:- Study data.

The summary results obtained using the screening model for the community level environmental variables are that:-

(i) malaria and breastfeeding duration are significant explanatory variables in the sub-model at 99% level of confidence. Nutrition status and immunization coverage are not statistically significant at 90% confidence level.

(ii) some effect of immunization are being picked up by malaria, such that exclusion of malaria from the model results in immunization becoming significant at 99% confidence level.

(iii) much of the effect of the nutrition variable is being captured by malaria although excluding malaria from the model still results in the nutrition variable being insignificant.

(iv) the directions of effect of each of these variables in the model were all as expected whereby the better-off groups displayed negative sign.

As was the case in the other two multivariate screening sub-models, variables that were found to affect the magnitude of the coefficients of one another in the screening process were cross tabulated. From the tables obtained, no pair of the variables were found to be significantly related in the model at 95% confidence level using the chi-square test.

In addition, an attempt was made to determine whether the malaria variable was masking the effects of community wealth. This was done by first constructing a community level variable on assets by applying the same criteria used in the construction of the household level assets variable discussed in the univariate analysis section but now treating the cluster as the unit of aggregation and involving all the households in the cluster irrespective of mother's marital status (thus including in the computation children born to never married women).

Using this criterion, those households owning either a permanent house or cash crop and land were categorized as better-off while those reported to own none of these assets or only to own land were categorized as poorer. In each cluster, the proportion of the better-off was computed and finally the distribution of these proportions for all the clusters was determined, yielding an overall mean of 56%. The clusters were reclassified into two groups based on the calculated proportions of the better-off. Those clusters with the proportions of the better-off in the upper 60 percent were defined as average and above while those with the better-off proportions in the lower 40 percent were defined as below average.

Clusters with proportions of the better-off of over 47 percent were categorized as the average and above while those with 47 percent and under were categorized as the below average. Finally, the cluster community assets categories were assigned to each of the children in that particular cluster who were included in the univariate model and in the multivariate sub-model for the community level environmental variables.

The univariate model for the community assets yielded results indicating that communities with average and above assets have significantly lower risk of child death with a beta coefficient of -0.226 and a standard error of 0.092 thus being significant at 99% confidence level. The age-specific hazard rates in the six age segments when this variable was included conformed to the overall pattern. The community assets variable was included in the multivariate sub-model it turned out to be insignificant with scaled deviance of 0.58 on 1 degree of freedom. In addition, community assets variable was found not to capture the effects of any of the other community-level variables included in the screening sub-model.

It was therefore concluded that malaria and other community-level environmental variables in the screening sub-model are not masking the effect of the community assets. Although only two of the community-level variables are found to be statistically significant in the sub-model, the other two (nutrition and immunization) are also to be considered for inclusion in the full model due to their importance to the study.

5.3 RESULTS AND DISCUSSION OF THE FINAL MULTIVARIATE MODELS USED IN THE DETERMINATION OF THE IMPACT OF ENVIRONMENTAL AND OTHER FACTORS ON INFANT AND CHILD MORTALITY

On the basis of the results of the multivariate sub-models presented and discussed in the previous section (section 5.2) and in consideration of the study objectives, a single data set was produced containing a total of 13 explanatory variables and their corresponding cell total exposures and deaths in the six age segments. The explanatory variables considered for inclusion in the final model comprised four community-level environmental variables (malaria, nutrition status, immunization coverage, and mean breastfeeding duration), two socio-economic variables (maternal education and type of marriage) and six proximate variables (consisting of four biological variables namely maternal age, birth order, birth interval and type of birth in addition to two household-level environmental variables, namely type of toilet facility and type of floor material) and finally the age interval variable.

5.3.1 Re-screening of the variables considered for the full model

Prior to the fitting of the full multivariate model, it was necessary to re-screen the variables considered for inclusion in the full model so as to determine their contribution or their explanatory power to the outcome variable which was the risk of death during infancy and childhood period segmented into six intervals. At this particular stage, the focus was on mechanisms and not on attaining a high level of precision in predicting the outcome variable. Results of the screening process for these variables are presented in Table 5.4.

Table 5.4. Results of the screening model for all the variables selected for multivariate analysis

Variable excluded from the model	Model		Changes from full screening model	
	Deviance	D.F	Deviance	D.F
None (full)	2049.2	5762	-	-
Malaria	2136.3	5763	87.1***	1
Nutrition	2049.4	5763	0.2	1
Immunization	2050.6	5763	1.4	1
Breastfeeding	2066.6	5763	17.4***	1
Mother's educ	2051.2	5764	2.0	2
Marital union	2058.5	5763	9.3***	1
mother's age	2052.4	5763	3.2	1
Birth order	2058.4	5763	9.2***	1
Birth interval	2069.6	5763	20.4***	1
Birth type	2091.3	5763	42.1***	1
Toilet facility	2050.0	5763	0.8	1
Floor material	2058.0	5763	8.8***	1

Key:-
*** Significant at 99% level using chi-square test.
** Significant at 95% level using chi-square test.
* Significant at 90% level using chi-square test.
D.F Degrees of freedom.

Source:- Study data.

Arising from the results of the screening process using the multivariate model containing all the variables considered for inclusion in the full model, the following can be stated:-

(i) all the variables except nutrition status, immunization coverage, mother's education, mother's age and type of toilet facility contribute significantly at 95% confidence level and above to the explanation of the risk of death in the six age segments.

(ii) much of the effect of the immunization coverage variable is still being captured by the malaria variable such that exclusion of malaria from the model results in immunization coverage variable being statistically significant at 99% confidence level. A cross tabulation of malaria and immunization indicated that a significant relationship exists between the two variables whereby children in malaria endemic areas were also mainly in lower immunization coverage areas. This provides an indication that children from non-malaria zones have an added advantage of being also in higher immunization coverage zones.

(iii) much of the effect of maternal education is being captured by type of toilet facility, such that by excluding the toilet facility variable from the model, the maternal education variable becomes significant at 95% level of confidence. This result is consistent with the expectation of the study and thus conforms to the socio-economic proximate determinants analytical framework and the modified version guiding this study. A cross tabulation of these two variables in the model also indicated that they were statistically significantly related whereby children of the highly educated mothers have also better toilet facility.

(iv) some of the effect of maternal age is being captured by birth order and type of marital union variables such that excluding type of marital union leads to maternal age becoming significant at 95% confidence level and by excluding birth order it becomes significant at 99% confidence level. Cross tabulation of maternal age and each of these two variables indicated that there was no statistically significant relationship between maternal age and type of marital union; there was, however a significant relationship between birth order of the children and their mother's age at time of their birth, whereby a large proportion of the first order births were born by mothers in outside the prime 20-34 ages.

(v) some of the effect of the type of toilet facility were being captured by the malaria, maternal education, type of marital union and type of floor material variables. However, removal of any one of these variables from the model does not alter the lack of statistical significance of the variable type of toilet facility. Cross tabulation of the toilet facility variable with these other variables yielded results indicating that there was no statistically significant relationship between toilet facility and malaria and type of marital union; there were, however, a statistically significant relationship between type of toilet facility and both maternal education and type of floor material. Children in households with better toilet facility have also in households with both better educated mothers and better floor material.

(vi) the direction of influence of the nutrition status variable's better-off category was not as was expected although its contribution in explaining the outcome variable was found not to be different from zero at any level of statistical confidence. This could be interpreted to mean that the advantage of being in the nutritionally better-off community is reduced when socio-economic and proximate variables are brought into play. The screening process also indicated that the nutrition status variable was capturing some of the effects of the variables type of marital union, maternal education, malaria and type of toilet facility. Analysis of the cross tabulations of the nutrition variable with each of these four variables indicated that there was no significant relationship between nutrition variable and any of these variables at 95% confidence level. The only relationship that became significant at 90% confidence level was between nutrition and malaria, whereby children in the better-off nutrition communities were also mainly in non-malarial communities.

For the variables that were found to be statistically significant in the screening model, a further scrutiny was done to determine the nature of their relationships with the other variables included in the screening model. This was done by cross tabulating the pairs of variables that resulted in changes in the coefficients of the others without necessarily changing the level of the overall contribution to the explanatory power of the variable in the model. The results of the analysis of the cross tabulations are summarized as follows:-

(i) the variable type of marital union was found to be significantly related to malaria and mother's education. A significantly higher proportion of the children in polygamous unions were also in malaria endemic areas. This was not surprising since the incidence of polygamy is predominantly in areas around the Lake Victoria basin and in Coastal region of Kenya which also are malaria endemic zones. A significant proportion of the children from polygamous unions also have mothers with low education. This was also expected since the majority of the better educated mothers are in monogamous marriages.

(ii) the birth order variable related significantly with mother's education, type of birth and preceding birth interval. A significantly larger proportion of children born to mothers with low and no education were of higher parity. The other observed relationship that could be attributed only to chance was the result that a significantly larger proportion of the multiple births were of birth orders 2 to 5. Birth orders 2 to 5 were also found to have had relatively shorter preceding birth intervals which was expected given the high fertility regime and its associated shorter inter birth spacings.

(iii) type of birth relates significantly with the mean breastfeeding duration in the community, preceding birth interval and the type of floor material. A large proportion of the multiple births were in communities with longer breastfeeding, in households with poorer floor material and had longer preceding birth intervals. Given a lack of theory in existence to explain these relationships, one can conclude that these were due to chance.

(iv) type of floor material relates significantly with type of toilet facility and mother's education, whereby a significant large proportion of the children in households with better floor material are also in households with better toilet facility and are born to mothers with 9+ years of education. This result is consistent with the study expectation and could be attributed to the strong linkage between education, public health knowledge and the standard of living in the households.

Finally, the correlation matrix for all the variables in the screening model was examined. It was observed that all the variables in the model except type of birth had very high correlation coefficient with the other variables in the model so it was excluded from the model. The other correlation coefficients for three variables, namely birth order, maternal age and birth interval were considered not to be high enough to cause concern.

Further scrutiny of these three variables was done by removing them from the model and noting changes in the overall mean death rate. It was established that they had insignificant effect on the overall mean estimate of the death rate. Most of the other parameter estimates in the model had correlation coefficients that were fairly low and for that reason, one can conclude that the estimates obtained using the model suffered from minimal multi-colinearity problem once the variable type of birth was removed from the model. On the basis of this last result, the variable type of birth was to be excluded from the final model to avoid the excessively high risk of death associated with it which may otherwise contaminate our results.

5.3.2 The final multivariate models fitted to determine the impact of environmental and other factors

In Chapter three section 3.5, it was mentioned that the strategy of considering the three groups of all the variables in the analysis as chunks would be the most appropriate method for entering the variables in the final model so as to determine both the impact and the mechanisms while utilizing the analytical framework guiding this study. The chunk of variables containing age interval and the community level environmental variables was entered first followed by the chunk of variables containing the socio-economic variables and finally by the chunk containing the proximate variables. The estimates obtained using the three multivariate models fitted are presented in Table 5.5 and the discussion of the impacts are presented in the sub-sections that follow.

Table 5.5. Main effects estimates from multivariate models with risk of death for children aged under 5 years in the six age segments as the outcome variable.

Variable	Model 1		Model 2		Model 3	
	Beta	S.E	Beta	S.E	Beta	S.E
Age interval						
1-<3 month	-1.937***	.171	-1.937***	.171	-1.936***	.172
3-<6	-2.205***	.166	-2.205***	.166	-2.205***	.166
6-<12	-2.276***	.138	-2.276***	.138	-2.274***	.138
12-<24	-3.024***	.149	-3.022***	.149	-3.022***	.149
24-<60	-3.828***	.165	-3.830***	.165	-3.840***	.165
0-<1 (Ref)						
Malaria						
None	-1.083***	.108	-1.011***	.011	-0.990***	.110
Endemic (Ref)						
Nutrition status						
Better	0.032	.096	0.067	.097	0.051	.098
Poorer (Ref)						
Immunization coverage						
Higher	-0.151	.103	-0.135	.103	-0.113	.103
Lower (Ref)						
Breastfeeding duration						
Longer	-0.379***	.096	-0.375***	.097	-0.369***	.096
Shorter (Ref)						
Mother's education						
1-8 yrs			-0.044	.103	-0.070	.110
9+			-0.334*	.179	-0.270	.192
None (Ref)						
Marital union						
Monogamous			-0.370***	.104	-0.376***	.106
Polygamous (Ref)						
Mother's age						
20-34 yrs					-0.204*	.111
<20, 35+ (Ref)						
Birth order						
2-5					-0.456***	.163
6+					-0.394***	.159
1 (Ref)						
Preceding birth interval						
24+ months					-0.463***	.107
<24 (Ref)						

Toilet facility				
Better			-0.095	.119
Poorer (Ref)				
Floor material				
Better			-0.467***	.152
Poorer (Ref)				
Model parameters				
Constant	-2.833	-2.562	-1.599	
Chi-square	2466	2449	2411	
D.F	7791	7788	7782	

Key:-
- *** Significant at 99% confidence level using two tailed t-test.
- ** Significant at 95% confidence level using two tailed t-test.
- * Significant at 90% confidence level using two tailed t-test.
- D.F Degrees of freedom.
- S.E Standard error of the estimate.

Source:- Study data.

5.3.3 The impact of community level environmental factors

It is clearly evident from model 3 in Table 5.5 that the two community level environmental factors that are statistically significant at 99% confidence level even after controlling for all the other variables included in the model are malaria and mean duration of breastfeeding. We also therefore reject the statistical null hypotheses that there are no differences in the risk of infant and child deaths in the communities classified by two categories of malarial prevalence and of breastfeeding duration after controlling for the other variables. This in effect could be interpreted to mean that the socio-economic and proximate variables included in the model cannot be used to adequately explain the effect of malaria and mean duration of breastfeeding in the community. It was the expectation of this study that the significance of these community level variables would diminish to insignificant levels with the inclusion of the proximate variables in the model yet in the three models one can only note an insignificant decline.

Using the parameter estimates for the malaria variable, the mortality risks for children communities where malaria is not endemic are on the average 37% lower compared with the mortality risks in the malaria endemic communities having taken into account the other factors. From the preliminary analysis it is certain that malaria is not masking the effect of community assets and the other community-level variables included in the model but it cannot be ruled out that it is masking the effects of other regional and socio-economic variables not included in the analysis. The model estimates also indicate that mortality risks for children in communities with longer mean breastfeeding durations of over 15 months have mortality risks about 69% lower relative to those in communities with 15 and under months of mean breastfeeding durations having controlled for the other factors.

The other two community level environmental variables included in the final model have statistically insignificant impact. In the discussion presented in section 5.3.1, it was mentioned that, although the immunization variable is statistically insignificant, much of its effect is being captured by the malaria variable in the multivariate model. However, when other factors in the model are controlled for, children in communities with high immunization coverage (over 67%) still experience mortality risks about 90% lower than those in communities with lower immunization coverage.

For nutrition, although the direction of the coefficient of the variable in the final model is in the unexpected direction, its magnitude of effect is not statistically different from zero. As was indicated in section 5.3.1, it can be concluded that when the effects of other community level, socio-economic and proximate variables included in the model are controlled for, nutrition status of the children in the community becomes less important as a mortality risk factor to such an extent that belonging to communities with relatively better nourished children provides no added advantage with respect to infant and child mortality.

5.3.4 The impact of socio-economic factors

Although only two socio-economic variables were included in the final model (model 3), it was only mother's education variable that performed as was expected. On the basis of the theory guiding the study, the observed statistical significance of the two socio-economic variables at 90% confidence level and above in model 2 was expected to be captured completely in model 3 which includes the proximate determinants. The results of model 2 can be interpreted to mean that when both community level variables and socio-economic variables are controlled for in the analysis, the importance of mother's education of 1-8 years in reducing the mortality of children aged under 5 years in rural Kenya becomes small.

The importance of 9+ years of maternal education is also seen to become a statistically insignificant factor in mortality reduction when proximate variables are controlled for. At the variable screening stage, it was established that the effect of maternal education is mainly being captured by one of the household-level environmental variables, namely the type of toilet facility. The estimates of the mother's education variable categories in model 3, show that the mortality risks of children born to mothers with 1-8 years of education is about 93% lower than those with no education. Those children whose mothers have 9+ years of education have 76% lower mortality risks relative to those whose mothers have no education.

The parameter estimates for the type of marital union variable in model 3 did not conform to the study expectation due to its persistence in statistical significance at 99% confidence level. At the screening stage, it was established that it is related significantly with maternal education which is an indication of its linkage with the standard of living and that it was also significantly related with the malaria prevalence which by deduction is an indication of possible interaction between culture and malaria.

The mechanism through which it acts to influence mortality risks for the under 5 year old children could not be explained by this study. However, it can be speculated that child health care and feeding practices in predominantly polygamous communities are traditional and hence are high mortality risk factors. Using the parameter estimates in model 3, children born to mothers in monogamous unions have on the average 69%

lower mortality relative to those in polygamous unions.

From the above discussion, it can be stated that although both 1-8 and 9+ years of maternal education have negative effect on infant and child mortality as per the study hypotheses, the multivariate analysis results indicate the effects of both are statistically insignificant in the full model. One can possibly add that at the present child mortality levels, maternal education of under 9 years is of no significant advantage. On the other hand, monogamous unions have both statistically significant negative effect on infant and child mortality although the mechanism through which it acts is unexplained by the study.

5.3.5 The impact of household environmental factors

The study results from model 3 show that type of floor material has a statistically significant effect at 99% confidence level even when all the other variables included in the model are controlled for. Children aged under 5 years in households with modern floor material have a substantially lower mortality risk. This result confirm the study expectation that better hygienic household dwelling environment as measured by the quality of floor material has substantial effect on reducing risk of death for the under 5 year old children in rural Kenya.

From the parameter estimates of model 3, the under five year old children in households with modern floor material have 61% lower mortality risks relative to those in households with poorer floor material. The significant relationship between type of floor material on one hand and maternal education and type of toilet facility on the other established at the variables screening stage also provides further evidence of the strong linkage between household-level environmental, standard of living and public health knowledge associated with better maternal education.

Although the variable type of toilet facility has statistically insignificant effect on risk of death for the under five year old children when the other variables are controlled for in the model, children in households with better toilet facility still have mortality risks about 91% lower relative to those in the households with better toilet facility. It can therefore be concluded that better toilet facility has negative effect on risk for the children aged under five years as was hypothesized in this study although this is not statistically significant in the multivariate context.

5.3.6 The impact of other proximate factors

Parameter estimates for the other proximate variables included in model 3 conformed to the study expectation. Children who were born by mothers at their prime reproductive ages (20-34 years) have statistically significant lower mortality at 90% confidence level when compared with those born by mothers in non-prime ages (<20 and 35+ years). The results indicate that children born to mothers in their prime reproductive ages have 82% lower mortality risks relative to those born to mothers in non prime ages. At the stage of screening the variable discussed in sub-section 5.3.1, it was established that effect of maternal age in the model was being captured by birth order variable. These results can be said to confirm the significance of the indirect relationship of the physiological strength of the mother with the biological strength of the child.

The variable birth order is a statistically significant factor at 99% confidence level in determining the risk of death for the under five year old children. Birth orders 2 to 5 and 6+ have significant lower mortality risks compared to those of order 1. Apart from the interaction between birth order and maternal age discussed earlier, it was also noted at the screening stage that birth order is related significantly with maternal education and birth interval variables. These relationships may have been responsible for the lack of perfect fit of the expected U-shaped mortality pattern by the three birth order variable categories in the model. The model's parameter estimates indicate that birth orders 2 to 5 have mortality risks about 63% lower relative to those of birth order 1 while those of birth orders 6+ have 67% lower mortality risks compared to birth order 1 even after controlling for other factors in the model.

Births with preceding intervals of 24 months and over have statistically significant lower mortality at 99% confidence level compared to those with intervals of under 24 months. The parameter estimates translates into a 63% lower mortality risks for those children with preceding birth interval of 24+ months relative to those with under 24 months. The impact of preceding birth interval variable could be much greater given the consideration that the first births who are also in high mortality risk group were coded in the analysis as having 24+ months of preceding birth intervals. However, these results conform to the study expectations.

Although the variable type of birth was removed from the analysis at the final model fitting stage for reasons discussed in sub-section 5.3.1, results from the preliminary analysis indicate that multiple births have a statistically significant excessively higher mortality at 99% confidence level when compared with the singletons. This was also consistent with the study expectations.

5.3.7 The impact of the age factor

From the three final multivariate models fitted to determine the impact of environmental variables and the other factors presented in Table 5.5, it is clearly evident that the variable age, segmented into the six intervals, is statistically significant at 99% confidence level in explaining risk of infant and child death in rural Kenya even after controlling for all the other factors. The parameter estimates for the age interval variable categories depicted a pattern indicating decline in risk of death with the increase in age and thus maintaining the pattern of the hazards in the intervals computed without including any of the explanatory variables.

Finally, arising from the results of the multivariate analysis presented and discussed in this chapter and the results of the univariate analysis presented and discussed in Chapter 4, a number of conclusions regarding the study hypotheses were drawn. The focus of the next chapter (Chapter six), therefore, is the presentation of a summary of the major findings of the study, conclusions drawn and recommendations based on these results.

It should be noted that few unpublished studies that have been undertaken at PSRI have yielded results which do not agree completely with some of the results of this study. The differences are mainly on the obtained estimates and explanatory variables. This could be attributed to differentials in methodologies applied and the data sets used. As mentioned earlier, these other studies used the mother as the unit of analysis and applied census based estimatiom methods in the analysis using relatively few cases contained in the sample survey data sets. This study has used the child as the unit of analysis and a methodology most suitable for analysis of a rare event using sample survey data.

CHAPTER 6

SUMMARY, CONCLUSIONS AND IMPLICATIONS

This study was undertaken to investigate the impact of environmental factors on infant and child mortality at household and community levels in rural Kenya. The summary, conclusions and implications of the study presented in this chapter will be discussed in two main parts. Part one focuses on the summary and conclusions of the study, and highlights two main issues beginning with the study design. The second issue highlighted in part one of this chapter is the consistency of the theory and the study data utilizing the results of the univariate and multivariate analysis and thus provides concluding statements on whether the data support or reject the study hypotheses. In part two of the chapter, the implications of the study findings are examined in terms of both policy and needs for further research.

6.1 SUMMARY AND CONCLUSIONS

Prior to the presentation of the conclusions of this study, the study design used to facilitate answering the research questions will be highlighted. The broad research question that was to be answered was whether environmental factors have impact on infant and child mortality at household and community levels in rural Kenya. Hence the broad hypothesis of the study derived from the available literature cited in Chapter one was that at both household and community levels, environmental factors have significant impact on infant and child mortality. For this broad study hypothesis to be translated into specific empirical hypotheses for testing, there was the need to select and use the most appropriate theory and conceptual framework to guide the study prior to the determination of the variables to be incorporated into the analytical (empirical) model.

A suitable conceptual framework, developed by Mosley and Chen in 1984 for studying child survival in developing countries, was adopted with some modification to facilitate incorporation of community level environmental factors as broad contextual factors in addition to socio-economic factors.

The empirical model used in this study depicted in Figure 2.2 comprises a total of 21 independent variables used in testing of the formulated empirical hypotheses while using risk of death for children aged under five years as the dependent variable. A proportional hazards regression model was applied on a subset of the 1989 Kenya Demographic and Health Survey data restricted to 5826 children born since 1st January, 1983 by ever married women interviewed in the survey and living in 326 rural clusters. In computation of community level nutrition variable, data on 3444 children aged 5 to 60 months gathered in these 326 rural clusters in the 1987 Rural Nutrition Survey was used. In addition, data on 6220 children for both ever and never married women in these 326 clusters collected in the 1989 KDHS were used to compute community level variables on immunization coverage, mean breastfeeding durations, and type of medical care provided to sick children.

Overall, the study data were assessed and found to be of good quality. However, it is important to note that this study suffers from the limitations of the proportionality assumptions imposed to facilitate use of the proportional hazards models in log-linear format, the problems associated with the use of household sample survey designs including assumptions of independence of observations regarding siblings, assumptions of fixed socio-economic and household level environmental conditions from January 1 1983 to survey date, and also the failure to control for the frailty factor among families or groups of children included in this study.

At the household level, the results of the univariate models established that three environmental variables included in the analysis are associated with lower risk of infant and child death. Children in households with modern toilet facility, better quality housing floor material and with less contaminated water have significantly lower risk of death relative to their counterparts in the worse-off categories. The data therefore support the study hypotheses that quality of toilet facility, quality of housing floor material, and quality of water in the household have a significant association with the risk of death for the children aged under five years in rural Kenya.

The environmental variable at the household level on distance to source of water supply was found not to be a significant factor associated with risk of death. Children in households with longer distances to source (over 60 minutes), have relatively insignificant lower risk of death. The study data reject the hypothesis regarding the association between risk of death and household crowding measured using the number of siblings aged under five years in the household.

At the community level, the results of the univariate models suggest that children in communities where malaria is non-endemic, with higher immunization coverage and with longer mean durations of breastfeeding have significantly lower risk of death at 99% confidence level compared to their counterparts in the worse-off categories. The study data support the study hypotheses regarding these community level variables that they have significant associations with the risk of death for children of age under five years. Community level nutrition status of the children was found not to be statistically important although children in communities with better-off nutrition status were found to have relatively lower risk of death compared to those in the worse-off category.

The study data therefore do not support the study hypothesis that better nutrition status in the community is a significant factor associated with lower risk of death. Similarly, the study data do not support the study hypothesis that children in communities practicing appropriate type of medical care in event of illness have significantly lower risk of death.

The study data were also able to support the study hypotheses on quite a number of other proximate and socio-economic variables included in the analysis as controls. Only a few of the study hypotheses regarding these sets of variables were rejected by the study data. Children born to mothers not in their prime reproductive ages (20-34 years), those born as birth orders one or 6 and over, those with shorter preceding birth intervals of under 24 months, and those who were multiple births were found to have significantly higher risk of death as per the study hypotheses.

Sex of child was found not to be a significant biological proximate variable associated with risk of death, although females were found to have insignificantly lower risk of death. With respect to the socio-economic factors, children born to mothers and fathers without any formal schooling, those born to mothers with no access to information, those born to mothers in polygamous unions, and those born in households without any or with below average assets have significantly higher risk of death relative to their counterparts in the better-off categories as per the study hypotheses. The study data reject the study hypothesis that father's occupation is a statistically significant factor associated with risk of infant and child death, although children whose fathers are in professional category have relatively lower risk of death compared to those children whose fathers are in non-professional occupation category.

The impact of environmental and other variables included in the study mainly as controls was assessed using three proportional hazard multivariate models fitted using the study data. After controlling for the other factors in the study, only one household level environmental variable was found to be statistically significant. Children in households with modern floor material have a statistically significant lower mortality risk estimated at about 61% lower compared to those in households with worse-off floor material. The study data therefore support the study hypothesis that better hygienic household dwelling environment as measured by floor quality has a substantial and significant impact on risk of death for the children aged under five years in rural Kenya.

Better toilet facility was found not to be statistically significant household level environmental factor after controlling for the other factors, but still children in households with better toilet facilities were found to have mortality risks about 91% lower relative to those in the worse-off category.

At the community level, children in communities where malaria is endemic and where mean breastfeeding periods are shorter (15 months or under) have higher mortality risks even after controlling for other factors. These results were not quite unexpected since malaria and breastfeeding could both have direct effect on infant and child mortality. It can therefore be concluded that either these variables have significant direct effect on risk of death or the proximate variables that would capture some of their effects were excluded from the analysis model. It is certain that the malaria variable is not capturing the effect of community assets in the analysis but we cannot rule out that it is not masking other regional effects since it was defined using geographic location.

Having given those considerations, the study data indicate that child mortality risk in non malaria communities is about 37% lower relative to those in the endemic malaria communities after controlling for the other factors. Since in the final full model the effects of nutrition, birth interval and immunization were controlled for, it can therefore be concluded loosely that longer mean durations of breastfeeding in the communities are probably providing additional but significant protection.

The study data indicate that children in communities with mean breastfeeding durations of over 15 months have lower mortality risks of about 69% relative to those in communities with 15 months or under mean breastfeeding durations after controlling for other factors. On the other hand, the study data reject the study hypothesis that immunization coverage is a statistically significant factor determining risk of infant and child death when other factors are controlled for. However, children from communities with immunization coverage of over 67% have mortality risks of about 90% lower than those from communities with coverage of 67% or under. The study data established that much of the effect of immunization coverage was being captured by the malaria factor. Regarding the impact of nutrition factor at community level, the study data reject the hypothesis that it has substantial impact on risk of death after controlling for other variables. It is established from the data that nutrition factor has an insignificant impact when other factors are brought into play.

As was mention before, the assessment of the impact of environmental factors on infant and child mortality was done by controlling for the effects of other proximate and socio-economic factors in addition to the age interval factor in the analytical model. The study data were therefore also able to support and reject some of the study hypotheses relating to these factors although they were not of study importance. The data were able to confirm the study expectation regarding maternal education. Although maternal education of 9+ years was a statistically significant factor in the socio-economic sub-model, its significance was completely reduced to insignificant level when proximate variables were controlled for in the model.

Much of the effect of the maternal education variable was captured by the variable type of toilet facility which is a household level environmental variable. It also appears reasonable to argue on the basis of the study data that at the present levels of infant and child mortality in rural Kenya, maternal education of less than 9 years has no significant reduction effect of infant and child mortality. One of the surprising findings of this study is the persistence of statistical significance at 99% confidence level of marital union variable even after controlling for other variables in the model. Children in polygamous unions were found to have a significantly excess mortality compared with those in monogamous unions. Since the effect of household assets was not controlled for adequately in the model, it can be argued that the marital union variable is masking some of assets effect in addition to cultural effects. The study data were not able to explain the mechanism through which polygamous union acts to raise the risk of infant and child mortality.

Regarding the impact of the other biological proximate variables in the final model, the study data support the hypotheses that children born to mothers in non-prime reproductive ages, those children who are of birth orders 1 and 6+, and those with preceding birth intervals of under 24 months have substantial and statistically significant higher mortality relative to their counterparts in the better-off categories even after controlling for other factors. Also at the preliminary analysis stages, the study data were able to support the study hypothesis that multiple births have significantly excess mortality compared with the single births although the impact of this factor could not be assessed in the final model due to its potential to distort the other parameter estimates upon its inclusion in the model.

6.2 IMPLICATIONS OF THE STUDY

6.2.1 Policy implications

The study results suggest that improvements in quality of dwelling units in the rural areas through use of modern floor material would facilitate significant reduction of infant and child mortality. This could have substantial cost implications given that only about one quarter of the total rural housing units have modern floor material. Improvements in housing quality could possibly be attained in the long run through improved incomes in the rural areas to levels that could lead to affordability of use of cement as floor material which has almost one to one correspondence with semi-permanent and permanent housing structures.

This calls for reformulation of an adequate and comprehensive rural housing development policy within the framework of the rural development strategy currently under implementation to focus on the quality of housing for the majority poor. In the short run, self help groups in the communities should be provided with incentives and financial support by both government and other agencies to supplement their efforts in improving dwelling units. For instance, some organized women groups exit already in rural areas that raises funds amongst their members on rotational basis to purchase iron sheets roofing materials.

The study results also suggests the need to intensify malaria control programmes in the communities in malaria endemic zones so as to reduce infant and child mortality. In smaller and isolated island countries such as Sri Lanka, malaria was eradicated through massive spraying. However, such an approach is not feasible for Kenya due to its size and location and sensitivity about pesticides. It appears that the most feasible approach would be continuous spraying of the malarial breeding grounds and use of malarial drugs for prevention and treatment. This too has heavy cost implications given that relatively large portions of lands around Lake Victoria Basin and the Coastal Belt are malaria infested zones.

Probably a community based approach in malaria control programme could be introduced and intensified in malaria endemic areas through expansion of training of the existing community health workers or creation of a special task force to educate the rural public on prevention and treatment of malaria as well as spraying of private and public land masses serving as mosquito breeding zones. Since a large proportion of children in low immunization communities were also found to be in malarial zones, the on-going immunization programme (KEPI) could be used to promote the required public health education on malaria prevention and treatment. In addition, successful malarial control progrmmes would also require joint government and international commitment to provide sufficient funds for research and development of better preventive and curative medical technology.

Other policy issues arising from the study results include the need for intensification of breastfeeding promotion programmes so as to achieve mean durations in excess of 15 months in communities and the promotion of female education beyond 8 years. Breastfeeding promotion programme could have minimal cost implications since there exist already programmes implemented by the Ministry of Health supported by international agencies such as UNICEF and WHO. Education of females beyond 8 years has heavy cost implications but has also other benefits apart from child mortality reduction.

The need to incorporate into the existing curriculum on population information education and communication (IEC) programme specific messages targeted for the potential and present parents on the relative higher risks of infant and child mortality associated with births at non-prime reproductive ages, birth spacings of shorter than two years, birth orders one and six plus, and the multiple births also come out quite explicitly from the study results. In addition, the study results also suggest the need for intensification of family planning services in the rural areas so as to achieve the mortality reduction benefits that go with inter birth spacings of 24 months and over.

The first part involving the IEC curriculum and its implementation has limited cost implication bearing in mind that the National Council for Population and Development is currently coordinating various governmental and non-governmental agencies participating in the population IEC programmes in rural Kenya. However, the second part that involves expansion of family planning services in the rural areas could have heavy cost implications especially if the desired target of readily available and high quality family planning services are to be provided.

6.2.2 Implications for further research

From the results of this study, the mechanisms through which malaria and breastfeeding variables act to affect the risk of infant and child death were not established. Further research needs to be done to establish these mechanism. Probably if actual clinical data on malaria infection levels as well as data on breastfeeding practices and intensity were used, a better understanding of the mechanism could be attained. It is also apparent from the results of this study that further research needs to be done to determine the mechanism through which polygamous marriage unions act to affect adversely the risk of infant and child deaths in rural Kenya. Further research on how overcrowding and malnutrition affect the risk of infant and child mortality within the Kenyan situation need to be done.

Regarding methodological issues, there is need to gather longitudinal data to facilitate analysis of infant and child mortality without resorting to using fixed socio-economic and other covariates in the cross-sectional data. There is also the need to sharpen future survey instruments to improve the quality of information gathered on morbidity of children, occupation of parents and other wealth related variables that appear to be so central in mortality studies and yet the available data on them are of very poor quality.

Appendix Table 4.1. Months of exposure in age intervals by all variables used in the study

Variable	Months of exposure in the age interval (months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
Sex of child						
Males	2836	5577	8031	14804	25080	42443
Females	2826	5570	7975	14747	24896	43224
Mother's age						
<20 years	743	1458	2118	4000	6860	12267
35+ years	914	1794	2565	4720	7866	12834
20-34 years	4005	7895	11323	20831	35250	60566
Birth order						
1	688	1353	1987	3741	6429	11633
6+	2060	4052	5796	10607	17793	29721
2-5	2915	5742	8223	15203	25754	44313
Birth interval						
<24 months	1497	2947	4249	7870	13327	24057
24+ months	4166	8200	11757	21681	36649	61610
Type of birth						
Multiple	138	257	357	672	1005	1275
Single	5525	10890	15649	28879	48971	84392
Water quality						
Less clean	4164	8196	11770	21737	36755	63095
More clean	1492	2939	4219	7784	13163	22480
Water source						
1+ hours	1172	2311	3304	6035	10222	17816
<1 hour	3801	7477	10765	19890	33460	57021
Toilet facility						
None and poor	1067	2094	2988	5443	8949	14805
Pit, flush	4593	9047	13012	24096	41008	70826
Floor type						
Not modern	4610	9066	12998	23904	40444	69156
Modern	1050	2077	3002	5635	9508	16475
Siblings ≤5yrs						
3+	2294	4530	6461	11806	19884	34548
<3	3369	6617	9545	17745	30092	51119
Mother's education						
None	1768	3473	4997	9260	15884	28546
1-8 yrs	3171	6247	8954	16497	27693	46508
9+ yrs	724	1427	2055	3794	6399	10613
Father's education						
None	866	1697	2407	4454	7493	13258
1-8 years	3106	6115	8795	16209	27454	47272
9+ years	1691	3335	4804	8888	15029	25137

(Appendix Table 4.1 cont.)

Access to information						
No access	1997	3924	5619	10378	17605	30652
Some access	3653	7199	10353	19107	32268	54876
Household asset						
Below average	2263	4457	6363	11572	19308	32522
Average and +	2676	5261	7587	14166	24109	41763
Father's occupation						
Non profs.	5093	10023	14384	26534	44847	76751
Professionals	570	1124	1622	3017	5129	8916
Marital union						
Polygamous	1135	2230	3197	5857	9611	16730
Monogamous	4220	8314	11947	22087	37547	64062
Malaria						
Endemic	2481	4865	6922	12592	20836	35260
Non endemic	3181	6282	9084	16959	29140	50407
Nutrition status						
Poorer	2490	4897	7034	13007	22014	37868
Better	3172	6250	8972	16544	27962	47799
Immunization coverage						
67% or less	3112	6119	8751	16090	27084	46064
>67%	2516	4960	7156	13282	22576	39109
Breastfeeding duration						
≤15 months	2047	4012	5724	10459	17458	29667
>15 months	3579	7065	10183	18900	32164	55339
Medical care provided						
Less approp.	2651	5221	7511	13978	23673	40372
More approp.	2993	5892	8448	15489	26153	45022

Source: Study data.

Appendix Table 4.2. Total deaths in the age intervals by all variables used in the study

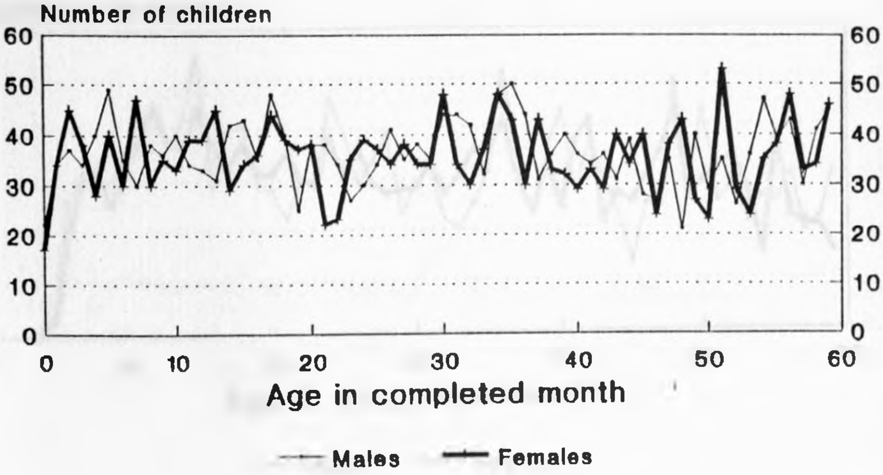
Variable	Total deaths in the age interval (age interval in months)					
	0-<1	1-<3	3-<6	6-<12	12-<24	24-<60
Sex of child						
Males	101	19	24	44	27	33
Females	65	28	28	43	43	18
Mother's age						
<20 years	33	7	11	17	16	8
35+ years	29	9	8	11	9	8
20-34 years	104	31	33	59	45	35
Birth order						
1	32	3	8	13	11	5
6+	60	18	19	31	15	23
2-5	74	26	25	43	44	23
Birth interval						
<24 months	48	14	20	35	21	17
24+ months	118	33	32	52	49	34
Type of birth						
Multiple	23	7	0	4	1	3
Single	143	40	52	83	69	48
Water quality						
Less clean	129	34	38	68	56	43
More clean	37	13	14	19	14	8
Water source						
1+ hours	38	14	18	16	16	9
<1 hour	116	31	27	67	52	41
Toilet facility						
None and poor	39	15	14	24	21	9
Pit, flush	127	32	38	63	49	42
Floor type						
Not modern	148	42	43	79	63	43
Modern	18	5	9	8	7	8
Siblings ≤5yrs						
3+	34	5	12	26	22	9
<3	134	42	40	61	48	42
Mother's education						
None	59	23	20	32	23	19
1-8 yrs	92	23	29	45	39	28
9+ yrs	15	1	3	10	8	4
Father's education						
None	29	18	11	13	9	11
1-8 years	87	22	29	51	46	26
9+ years	50	7	12	23	15	14

(Appendix Table 4.2 cont.)

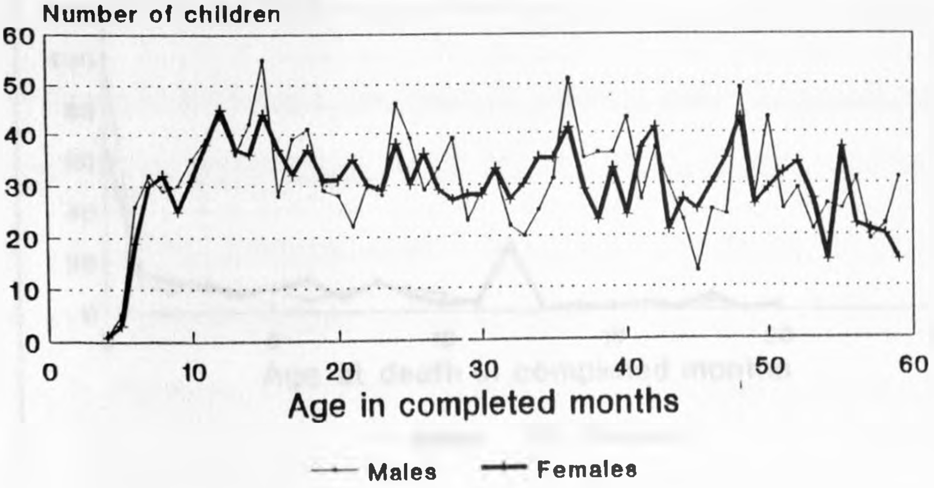
Access to information						
No access	60	22	25	36	28	18
Some access	106	25	27	51	42	32
Household asset						
Below average	59	29	28	52	41	26
Average and +	92	14	18	26	27	20
Father's occupation						
Non profs.	147	45	50	77	65	50
Professionals	19	2	2	10	5	1
Marital union						
Polygamous	45	16	16	26	26	17
Monogamous	109	29	31	56	38	32
Malaria						
Endemic	97	35	38	66	60	37
Non endemic	69	12	14	21	10	14
Nutrition status						
Poorer	82	23	26	38	27	22
Better	84	24	26	49	43	29
Immunization coverage						
67% or less	97	28	35	56	46	41
>67%	68	19	17	29	23	9
Breastfeeding duration						
≤15 months	71	30	25	45	33	17
>15 months	94	15	27	42	37	34
Medical care provided						
Less approp.	124	27	35	56	50	37
More approp.	41	18	17	31	20	14

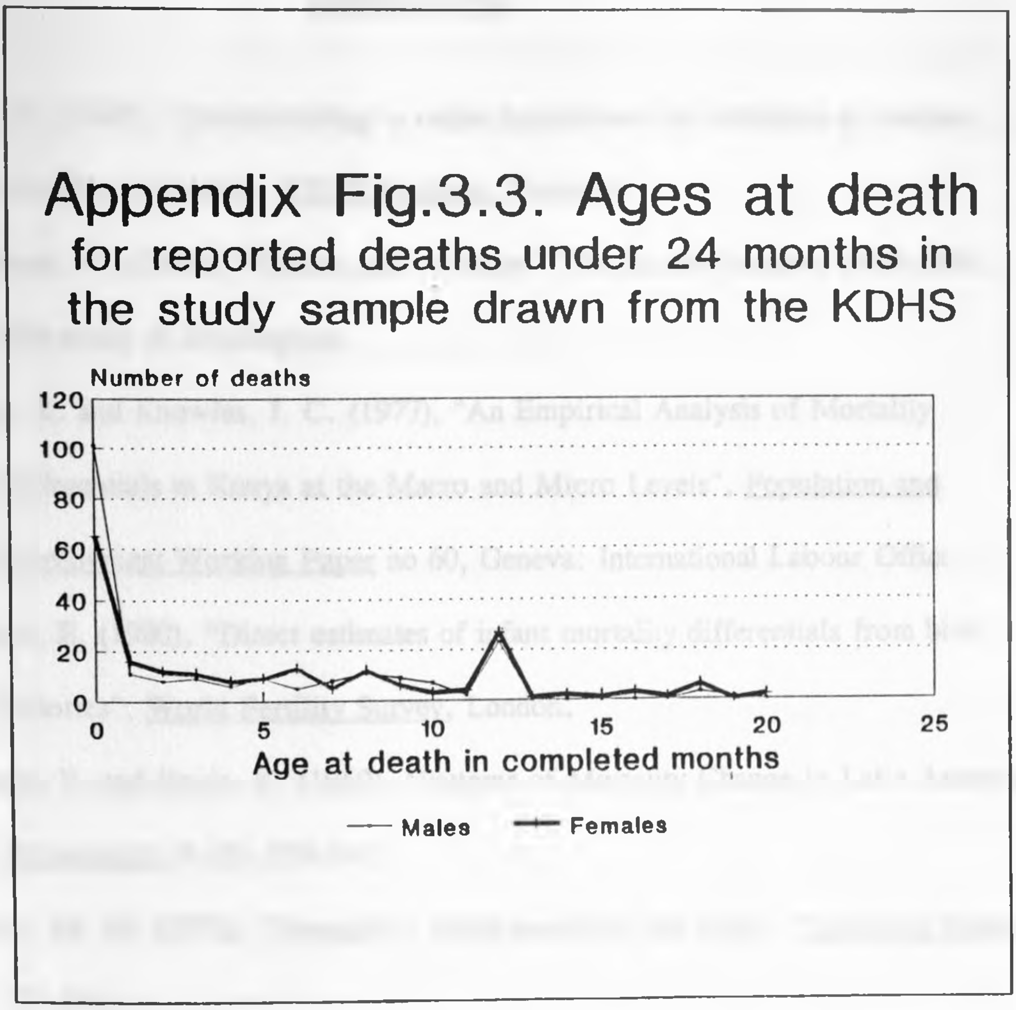
Source: Study data.

Appendix Fig.3.1. Current ages of the children reported alive in the study sample drawn from the KDHS



Appendix Fig. 3.2. Current ages of children whose anthropometric data were taken in RNS and used in this study




Appendix Fig.3.3. Ages at death
for reported deaths under 24 months in
the study sample drawn from the KDHS
Number of deaths
120
100
80
60
40
20
0
0
5
10
15
20
25
Age at death in completed months
Males
Females

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