ENVIRONMENTAL RISK FACTORS OF CHILDHOOD MORTALITY IN KENYA: EVIDENCE AND POLICY IMPLICATIONS

BY

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DECLARATION

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

LOUISE N. NDUNYU

This thesis has been submitted for examination with our approval as University supervisors.

-------------------- 6/11/96

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DEDICATION

To

A keen observer of life once said, "no man can fail, if some one person sees him successful". My success is owed to my parents, J. Ndunyu and E. Wanjiku, and my grandmother, Loise Njeri Mwaniki, who 'believed in me' and held without wavering to the divine plan; to them I dedicate this piece of work.

ABSTRACT

What is the impact of environmental factors on child death? How do these intervening variables operate to bring about exposure and susceptibility to infections and or malnutrition and finally child death?

The broad objective of this study is to identify and analyze the environmental risks of early death and to examine in some detail observed social factors which may influence these effects.
The KDHS, 1989 data was used in this analysis so as to assess its usefulness in undertaking such a study.

After perusing through the literature review, it was evident that all the environmental factors studied have been found to have a strong relationship with childhood mortality. It is on this basis that the environmental risk factors used in this study have been selected namely; household size (as a measure for overcrowding), source of water supply, type of housing and type of toilet facility. These risk factors are quantified so as to determine their strength in predicting child death.

In order to understand the role of these factors on mortality, two techniques are used in the study: Trussell's technique for the estimation of childhood mortality using defective data and Logistic Regression model using the Statistical Package for Social Sciences (SPSS) for analysis.

The findings confirmed that although under-five mortality rates have declined over the years, it is still very high at both the national (107/1000 live births) and provincial levels. This is largely reflected by environmental factors at household level as the mortality indices for the environmental variables are very high. In particular, are sanitation and water supply which have mortality estimates of 204/1000 live births for those with no toilet facilities and 425/1000 live births for those using lake and pond.

The logistic regression results also indicate that water supply is a high risk factor in determining mortality of children . Lake users are at (odds ratio = 2.0) twice the risk of experiencing child mortality vis a vis users of house-piped water. Mothers with no education are affected a great deal more by environmental risk factors than those with primary education. Mothers with no education using lake and public tap as their main source of water supply are at (odds ratio = 5.9; odds ratio = 3.7) six times and four times the risk of experiencing child mortality vis a vis users of house-piped water. As you move higher in the educational level, the environmental risk variables cease to be a risk in childhood mortality. This could mean that mothers who have gone to school have an advantage of knowledge in how to manipulate the adverse environmental conditions so as to protect their family members for better health.

The results from both techniques indicate an inverse relationship between number of household members and risk of childhood mortality. When household members are more than ten, this relationship is converse so that the risk of childhood mortality increases. We could infer that in rural Kenya where 85% of the population resides, overcrowding is rarely an issue. Members of the household sleep in different houses/huts according to the set traditional norms.

In summary, clean water and sanitation provide an important strategy for the reduction of environmental pollution and when available contribute greatly to the achievement of environmental health care.
Planners must look seriously into intervention programs which could accelerate provision of safe drinking water and access to sanitation services. The involvement the community in the planning and implementation of such programs should be encouraged.

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CHAPTER ONE GENERAL INTRODUCTION

1.1 INTRODUCTION

One of the most gratifying phenomenon of the twentieth century has been the decline of mortality rates in general and in particular infant mortality (from 184/1000 live births in 1948 to 104/1000 live births in 1979, census data; and to a further 62/1000 live births, KDHS,1983). Since World War II, many of the developing countries have realized gains in life expectancy at least three times as large as those achieved in Western Europe at a comparable stage in its mortality transition (Gwatkin, 1980). "Declining infant mortality explains much of the general decline in mortality". (DaVanzo, 1984, pp.1).

Besides the sheer value of life, reducing infant mortality has high priority for developing countries because children are an investment for both the family and the nation; and also reduced mortality is often followed by reduced fertility, a goal desired by Kenya. The goal of development is to endeavor to improve the length and quality of life.

Children, particularly infants, are highly vulnerable to adverse environmental conditions. It is this sector of the population whose health, good or poor, reflects the state of the environment. The infant mortality rate (IMR) and the child mortality rate (CMR) are often used as indicators of environmental conditions. The rapid growth of densely populated, predominantly low-income settlements in the cities of the Third World has come to constitute one of the most serious threats to health. Available statistical information and studies based on evaluation of living conditions in low-income settlements suggest that three major types of pathology are emerging two of which are:

a) Infectious and gastrointestinal diseases, often termed "diseases of poverty". They are today a major source of morbidity and mortality in children.

b) Chronic degenerative diseases associated with poor living and working conditions.

With regard to infectious and gastrointestinal diseases, it is currently estimated that up to 44.4% of all deaths to children under 4 years of age can be directly accounted for by repeated episodes of diarrhoeal disease. Respiratory infections and nutritional deficiencies, both of which are closely associated with poverty, overcrowding, and major causes of morbidity and mortality in young children.

The target set by the World Population Plan of Action (WPPA,1974) for countries with high mortality rates of an expectation of life at birth of at least 50 years and an IMR of less than 120 per 1000 live births by 1985 was largely achieved in 1990. Also a progressive attainment of an average life expectancy of 62 years by 1985 and 74 years by the year 2000 for the world as a whole was achieved then.

Table 1.1.1 Demographic indicators (1991)

Region	IMR per 1000 live births	CMR per 1000 one-year olds	e_0 at birth
World	64	38	63
Developed regions	12	3	74
Developing regions	71	44	61
	64	44	60

Source: Environmental Data Report, 1989/90

In Kenya, post-neonatal mortality is higher than neo-natal mortality since the IMR is high. A reasonable assumption is that as the IMR drops, then neo-natal mortality rate will be significantly higher than IMR as is the case in developed countries. Half of all deaths occurring each year in Kenya are deaths to children under 5 years of age although their proportion in the total population is much less.

The available evidence from the literature review indicates that most of deaths in this early stage of life are preventable so that improvements in water and sanitation and related environmental conditions can play a significant role in further ameliorating mortality. This conforms to well-known evidence from many developing societies as well as historical European populations where these factors significantly improved the life chances of infants and children.

In conclusion, it is appropriate to state that the goal of the government in reducing infant mortality is clearly declared in the policy guidelines. Thus, it is in their interest to know exactly what has contributed to the rapid decline and the factors that have kept the decline slow in the recent past. In the circumstances, if further reductions in the level of child mortality are not to be hindered, greater effort should be marshalled towards better environmental conditions.

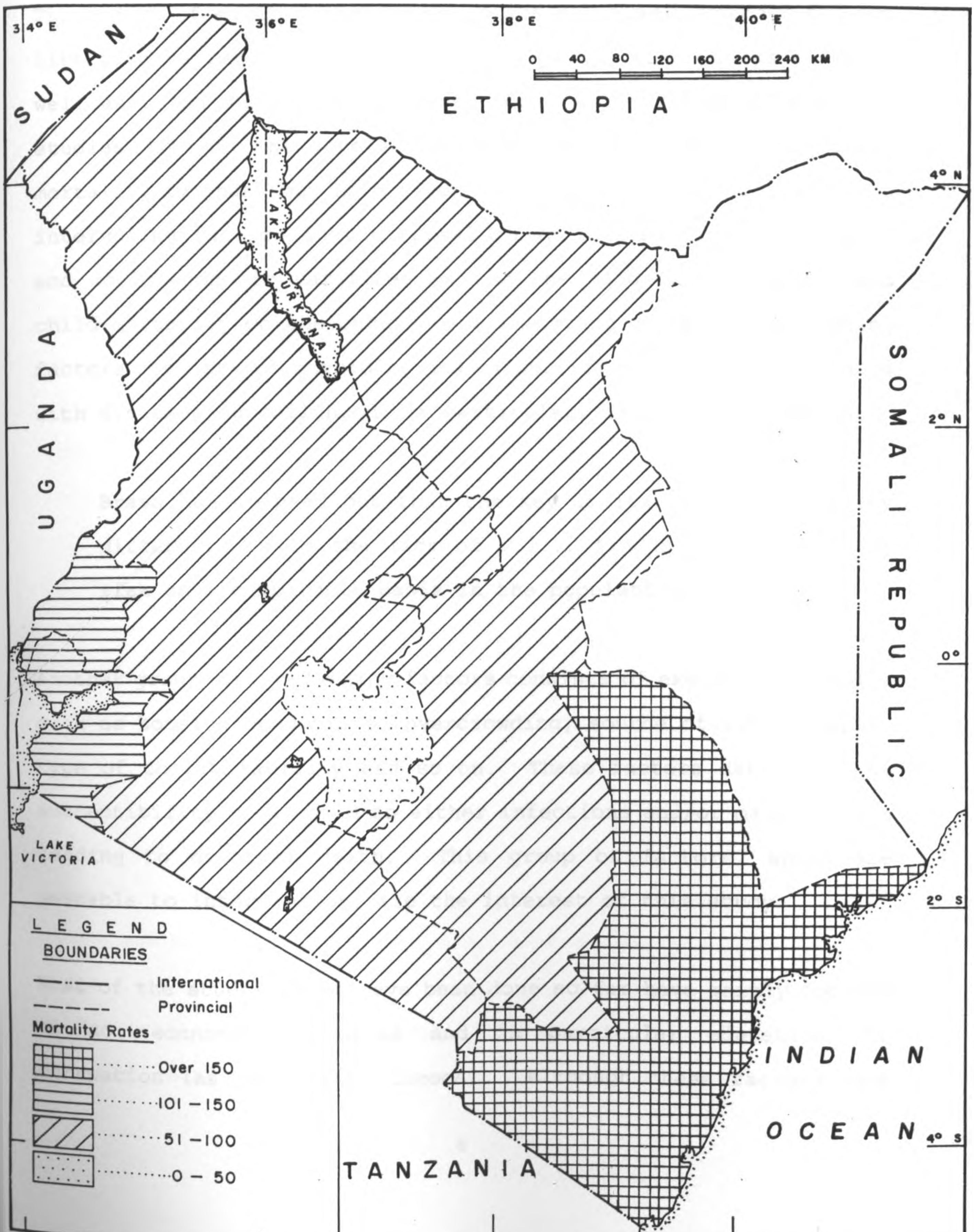


Fig. 1 : CHILDHOOD MORTALITY RATES (q5) BY PROVINCES FOR THE TEN-YEAR PERIOD PRECEDING THE SURVEY, KENYA DHS, 1989

1.2 PROBLEM STATEMENT

The impact of environmental factors are relatively unknown and are likely to be important in identifying groups with excess risks as well as being subject to intervention. A limitation of previous studies done on the levels and determinants of infant and child mortality is that they have given relatively little information on intervening factors in the causal chain leading from demographic and socio-economic variables on the one hand and to infant and child mortality on the other. One important group of intervening factors consists of morbidity and malnutrition which is associated with diseases in childhood, in particular, infectious diseases.

> Brass has pointed out that the key limitations of mortality differentials is the lack of ...... finding the numbers at risk on a comparable basis in the population.

Another group of intervening factors consists of exposure variables such as housing conditions, overcrowding, source of water supply, type of toilet facility and so on. These factors determine the susceptibility of a child to either infections and/or malnutrition leading to eventual death. This group of factors, which are amenable to intervention, are the interest of this study.

Most of the studies that have been done so far have mainly focused on socioeconomic variables and in particular education and occupation (as proxies of income). Although these factors have been shown to be inversely proportional to infant and child mortality, their effect is indirect and does not explain the cause and effect of the dependent variable, mortality.

Several studies have revealed marked differentials in living conditions among regions in Kenya yet scant evidence exists on the environmental risk factors of infant and child mortality. Thus policy makers are confronted with a vast grey area when questions of efficiency and equity are raised in the location of public goods which enhance the standards of living of the population. This study intends to identify factors amenable to intervention, or those which can act as indicators of need for policy makers to use in resource allocation.

Currently, it is a common sight to see heaps of dumped garbage all over the cities and towns in Kenya. Most low-cost government houses are too archaic and not fit for human habitation. They still have communal bathrooms and use buckets for toilets. This is not to mention the vast numbers of slums that have invaded the major towns in the country. stool littered all over the compounds and stagnant water from drainage and rain is the order of the day in most urban residential areas. These are breeding places for flies and mosquitoes. Effort should be geared towards improving these conditions and reconstructing archaic housing to replace them with improved or modernized ones with better facilities. In this way the hazard faced by young children through intestinal infections such as cholera, hepatitis and diarrhoea which are spread by the faecal-oral route could be reduced.

Finally, a low infant mortality rate (IMR) and child mortality rate (CMR) also means a high life expectancy at birth, (e_o), so we must aim at reducing the IMR and CMR.

1.3 BACKGROUND TO THE STUDY AREA

Kenya lies on the eastern coast of Africa, along the equator, with a surface area of 582,646 sq.km. It is bordered by Ethiopia, Somalia and the Sudan to the North and the Indian Ocean to the East, Uganda to the West and Tanzania to the South.

Its marked topographical and climatic variations make it the most geographically diverse area in eastern Africa and significantly shape the distribution and livelihood of Kenya's people. Kenya is primarily dependent on agriculture and about 85% of the population lives in the rural areas occupying 17% of the total arable land and survive on farming and or livestock. Coffee and tea are the main export crops. Other economic activities that help boost the GDP are tourism, forestry and fishing.

Kenya is divided into seven major administrative areas known as provinces which are further subdivided into 41 districts, numerous division, locations and sub-locations. The Nairobi area has a special provincial status.

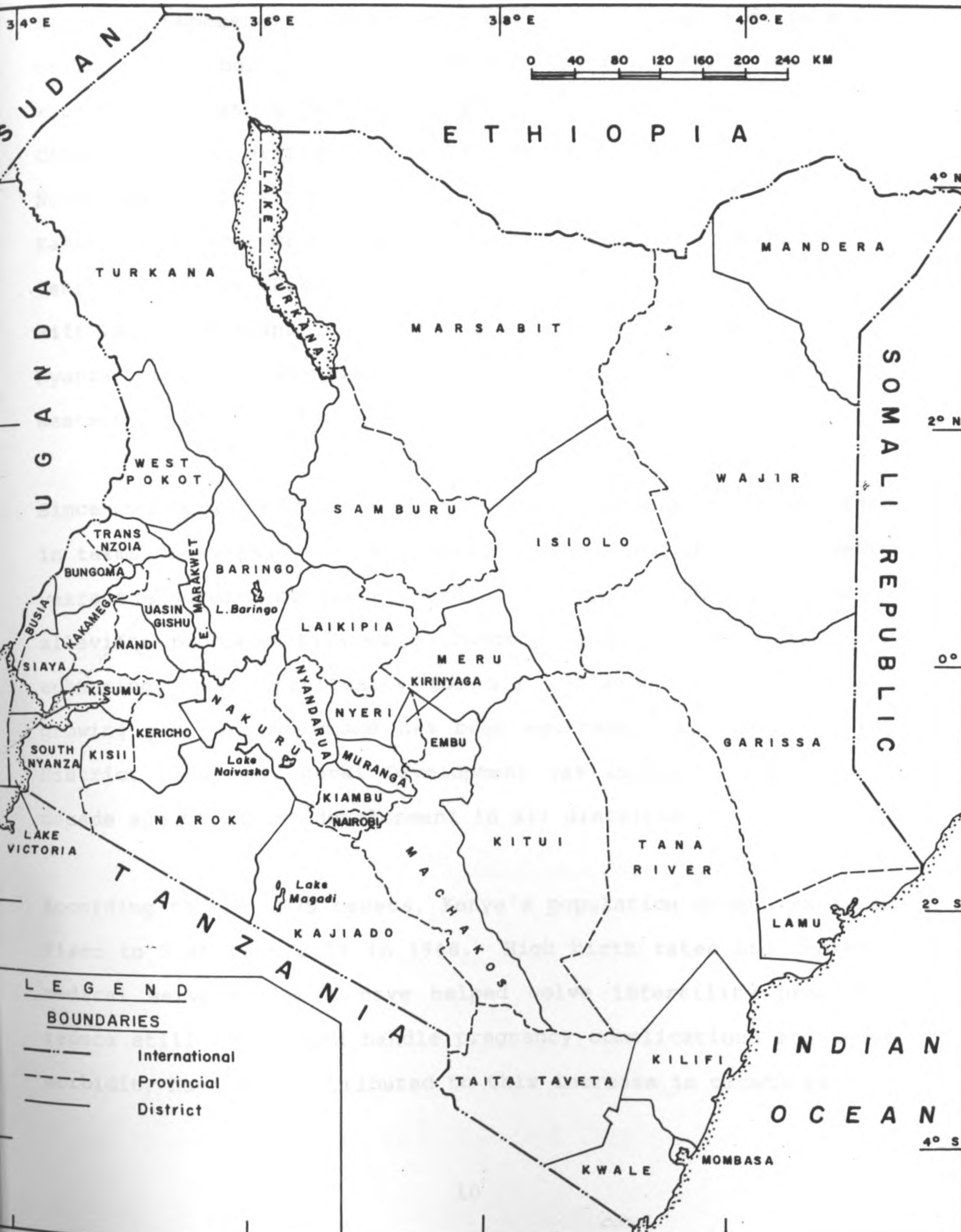


Fig. 2 : ADMINISTRATIVE UNITS OF KENYA

Kenya is composed of 70-80 ethnic groups with about a dozen major tribes and tribal groupings. The provinces are still identified with one (or, at, a few) ethnic groups.

Coast province: miji kenda; Taita, Taveta

North-Eastern province: Somali

Eastern province: Orma, Rendille, Boran; Meru, Embu; Kamba

Central province: Kikuyu

Rift Valley: Turkana, Pokot, Samburu; Kalenjin; Maasai

Nyanza province: Luo; Kisii, Kuria

Western province: Luhya

Since independence in 1963, Kenya has achieved substantial progress in terms of overall economic development. Throughout the twenty years the government has adopted social and economic policies to alleviate problems related to hunger, ignorance and disease by enhancing equal opportunity for all citizens, and a high and growing per capita income has been equitably distributed. The District Focus for Rural Development was initiated more than a decade ago to ensure development in all districts.

According to the 1979 census, Kenya's population growth rate had risen to 3.8% from 2.5% in 1948. High birth rates and improved medical services which have helped solve infertility problems, reduce still births and handle pregnancy complications and lower morbidity have all contributed to this increase in growth rate.

Table 1.1.2 Demographic indicators of census years

Variable estimate	1948	1962	1969	1979
Pop. (millions)	5.4	8.6	10.9	16.1*
TFR (No.)	6.7	6.8	7.6	7.9
Crude birth rate (per 1000 pop.)	50	50	50	52
Crude death rate (per 1000 pop.)	25	20	17	14
Natural rate of pop. increase	2.5	3.0	3.3	3.8
IMR (per 1000 live births)	184	126	119	104
e_0 (years)	35	44	49	54

* Adjusted for under-enumeration
source: Unicef 1989.

The government of Kenya is making concerted efforts to curb the population growth rate as well as improve the well-being and quality of life of the population.

Infant mortality rate has declined from about 180 per 1000 live births in the mid 1940s to 125 in 1959, 119 in 119 in 1969 and 104 in 1979 and 69/1000 in 1989. This represents a decline of about 20% per decade for the last 20 years.

51% of Kenya's total population is below 15 years of age indicating a very young population and a high dependency ratio. The under fives alone constitute about 21% of the total population. About one of every three Kenyans who dies below the age of five, compared to one in twelve in developed countries.
Health condition have improved as indicated by birth and death rates, life expectancy and nutritional status but under five mortality rate is still very high and infectious diseases are

prevalent. Kenya's major health concerns can be grouped into three:

a) Diseases related to poor environmental sanitation for example, amoebiasis, enteritis, dysenteries and other intestinal parasitic and diarrhoeal diseases.

b) Parasitic and infectious diseases: malaria, mainly found in L.Victoria in Western Kenya, the Coastal region and the Mwea irrigation scheme; sleeping sickness; schistosomiasis etc. c) Diseases of the respiratory system. These are such as pneumonia, tuberculosis, bronchitis and whooping cough and are mainly found in high altitude areas.

Together, these three groups of diseases accounted for nearly 705 of all deaths reported in 1980 and over 60% of the total reported morbidity. About 33% of reported childhood deaths have malnutrition as a contributing factor.

1.4 OBJECTIVES OF THE STUDY

1.4.1 General objectives

In broad terms, the objective of this study is to identify and analyze the environmental risks of early child death and to examine in some detail observed social factors which influence these effects.

1.4.2 specific objectives

Specific objectives are as follows:

i) To determine the overall probability of surviving between birth and exact age 5 in each Province using Trussell's technique and assuming North family model life tables.

ii) To calculate life expectancy at birth, e_0, by Province.

iii) To examine the 'exposure to the risk variables', for example, density of persons per house, availability of toilet facilities etc. of those still alive at interview compared to those who have died.

iv) To quantify the strength of the above factors for predicting child death.

v) To examine the interactions between these selected socio-environmental variables.

vi) To provide the results to policy makers in planning and resource allocation at the national and regional level.

1.5 JUSTIFICATION OF THE STUDY

Factors which influence the death rates of children under five years of age include maternal health care, drinking water quality, sanitation facilities, nutritional status and housing conditions.

Studies done to understand the factors influencing infant and child mortality have merely confirmed that differences exist between African countries and even within countries (Gaisie, 1984, Kandeh,1987). No suggestions have been made on how the social, economic and environmental factors operate to influence child mortality. The inter-relationships of underlying and proximate determinants of child survival developed by Mosley and Chen (1985) and modified by van Norren and van Vianen (1986) attempts to set out the mechanism by which different environment and different patterns of behaviour act as proximate determinants of levels of mortality in developing countries. This recognition of the importance of environmental factors on disease ecology and also behaviour which can be largely induced by cultural factors may be the missing link needed in the study of infant and child mortality differentials in Africa. This is so, as one can recall that these so called tropical diseases were prevalent either in endemic or epidemic forms in the temperate zone sometime ago and were brought under control or eliminated not so much by specific measures but more through changes in the physical and social environment (Yumkella, 1988).

Causes of death in the first 28 days of life are mainly due to birth injuries resulting in asphyxia and prematurity leading to low birth-weight. However, with advancing age, gastroenteritis and pneumonia are the most common causes of death among infants during the post-neonatal period. Respiratory infections, for example, tuberculosis, diarrhoea and malaria are also common causes of death. Diarrhoeal diseases contribute significantly to morbidity during the first two years of life, and when the joint effects of this problem and measles is compounded by malarial attacks their impact on morbidity and mortality during these ages is very substantial.

A strikingly high percentage of childhood deaths to those aged 1-4 years is caused by measles. Malnutrition is also a leading killer of children in this age group. When a child is malnourished its body resistance is weakened and becomes susceptible to any of the infectious diseases. A malnourished child is therefore most vulnerable to the environmental hazards surrounding him.

Normally, environmental conditions have an important effect on mortality rates, depending on whether or not the environment is favourable to various disease organisms and their vectors. Post-neonatal causes of death all have something in common in that they are related too poor environmental conditions and they can be avoided. If hygiene is poor (as judged by housing, water supply, and the disposal of excreta and rubbish), then illness will be common in all age-groups, especially among children. For example, overcrowded houses facilitate the spread of tuberculosis and respiratory infections. A poor water supply results in children being dirty and developing various skin diseases. An absence of latrines, or a failure to use them, means that the grounds will be soiled with stool with the easy spread of intestinal worms. Poor disposal of rubbish will lead to increased fly-breeding and likelihood of a spread of diarrhoeal disease.

Most parts of rural Kenya have no access to safe drinking water and sanitation facilities (as exhibited below) and therefore they tend to have high infant and child mortality rates.

Table 1.1.3 Trends in access to safe drinking water & sanitation services

	urban			rural			total		
	1970	1975	1980	1970	1975	1980	1970	1975	1980
% pop. with access to safe drinking water	100	100	85	2	4	15	15	17	26
% pop. with access to sanitation services	85	98	89	45	48	19	50	55	30

Source: Environmental Data Report, 1989/90

Many diseases in childhood are preventable by such large-scale methods as improved water supplies and sewage disposal systems, improved housing conditions and by means of health education. It is in societies where the lowest standards of living prevail that the individual is most completely at the mercy of his environment thus highest mortality rates found here.

As it has been clearly stipulated in the main objectives of this study the results will assist policy makers in planning and resource allocation both at the regional and national level. Kenya's Gross Domestic Production (GDP) growth rate is at 4.1 which is fairly reasonable.

Table 1.1.4 Economic indicators

Pop. (million) 1989	GNP per capita ($) 1989	Average annual growth rate ($)	Average annual Rate of inflation (%)		GDP	
		1965-1989	1965-80	1980-89	1965-80	1980-89
23.5	360	2.0	7.2	9.0	6.8	4.1

Source: Environmental Data Report, 1989/90

However, it is not so much the level of the GDP of a country, but the distribution and the share that goes to the poorer half of the population that seems to have most effect on infant mortality (Grant,1982). Economic development without simultaneous improvement in social welfare, and household characteristics, is likely to raise the infant death rate even more. A classic example is that of the Netherlands where the infant mortality decreased from 200 per 1000 a hundred years ago to 50 per 1000 fifty years ago and less than 10 per 1000 in 1980. Improved housing conditions, provision of safe drinking water and propagation of breast-feeding contributed even more to this decline than the almost 100% coverage with childhood vaccinations and the developments in medical technology.

Some questions to be addressed are:-

1. What environmental and household risk factors for child mortality are significant for planning?

   How does the prevalence f identifiable risk factors vary across regions?

This study attempts to link the gap between education and childhood mortality.

1.6 LIMITATIONS AND SCOPE OF THE STUDY

The study of mortality in Kenya (as in Africa) has been a difficult task due to poor records from routine sources such as vital registration, censuses and also surveys. Such is the case with the Kenya Demographic and Health Survey (KDHS, 1989), the source of data used in this analysis. Nevertheless, KDHS, 1989 is in a sense unique as unlike other surveys and census records, it incorporates a wide variety of environmental and health variables and thus makes it possible to carry out this kind of study and allows the application of the risk approach to identify the hazards of excess child mortality. However, the sample sizes in KDHS,1989 data leave a lot to be desired as they are too small and make the application of demographic techniques for mortality analysis almost impossible to carry out especially at district level and by other differential. Some errors in this secondary data are quite gross for example, sample sizes in the total number of children born in the last five years by Province does not seem to be consistent. Another experience in this analysis is that some environmental variables like type of housing material for the walls and roof had to be left out as they displayed empty tables on the computer printout. This could be due to the small number of total children dead which then reduces even further when computed by environmental factors. Consequently, irregularities in the mortality rates estimates is observed and in some instances with very absurd estimates. Errors of misreporting and omissions of both births and deaths are also present. This incompleteness of data makes it impossible to compute accurate results.

The information in the Kenya DHS data is, nevertheless, very useful and is indeed, some of the most comprehensive and recent data available nationwide. however, the environmental variables constitute some intrinsic components which are difficult to estimate especially in a quantitative data gathering like in Demographic Health Surveys.

For example: number of household members - one needs to know the number of rooms, ventilation situation, number of people sleeping in each room and the general sleeping arrangement so as to determine the extent of overcrowding.

Owing to the fact that KDHS data was mainly rural oriented variations between regions on housing type (material of roof) are relatively small and may not be useful as a differential.

Type of toilet facility - a number of questions may arise: is the toilet made use of by the members and how often is it cleaned? Is a disinfectant used in cleaning? Is the pit latrine modern with a pipe for fumigation (VIP) or is it the old type?
Age children use adult toilet - how is the child toilet trained before using adult toilet? Sanitary habits are not easily measured but may be observed. These habits include washing of hands after each toilet visit and before eating; clean and well-drained compound, grass, and so on.

Disposal of rubbish and other household refuse - how is refuse disposed of?
Source of drinking water - is water treated for drinking and if so by what method?

On the field observation is necessary if certain intrinsic information is to be captured for detailed exposition of data.

Thus the consistency and reliability of Kenya DHS data on mortality is questionable and leaves a lot to be desired both for analysis and policy-making. A similar observation has been made in the DHS World conference (August,1991) in which Kenya was one of the three countries excluded from the main analysis of socio-economic differentials as there were solid grounds for doubting the validity of national estimates.

The whole concept of factors influencing child survival is a complex process. This complexity has been illustrated by Ewbank et al (1984) in their analysis of infant mortality among women of different educational status in Kenya. It was apparent from the results that not only is infant mortality not an artifact of environmental or cultural differences but that education is not the only important determinant. It may well be therefore that the frustrations encountered by previous researchers in explaining differentials was likely because most of the studies concentrated more on socioeconomic differences paying little attention to cultural and environmental differences. This resulted in having only a small proportion of the mortality differentials explained. The methodology used in this study, "The risk approach to the study of mortality", is not new, but has usually been confined to a narrowly medical orientation to health problems especially in developed countries. Use of this approach opens a new dimension to mortality studies done at PSRI, University of Nairobi.

CHAPTER TWO LITERATURE REVIEW

> The more extensive a man's knowledge of what has been done, the greater will be his power of knowing what to do.
>
> BenjaminDisraeli

2.1 INTRODUCTION

Many studies have been carried out in a bid to investigate the factors that affect infant and child mortality levels and differentials and the strength of association between these factors (independent variables) and infant and child mortality (dependent variable) as will be underscored later in this chapter. These factors may fall under the following classification: socio-economic, socio-cultural, environmental and demographic. various indirect techniques for estimation of mortality rates have been used in developing countries where data is defective and incomplete. The data sources for mortality studies may be derived either from secondary sources such as demographic surveys, civil registration system and censuses or from primary data where the investigator collects information by questionnaires, longitudinal studies, focus group discussion or interview.

This chapter intends to examine the various infant and child mortality studies that have been done in different parts of the world. It is divided into two major sections. The first section deals with studies in developed countries; the second section explores studies done in the Latin America and Asia, Africa and finally Kenya, with special reference to studies done at the Population Studies and Research Institute, University of Nairobi. Special emphasis has been given to studies carried out in the developing countries since they have comparable mortality levels.

2.1.1 Developed countries

In the developed countries of the world, over 97 percent of all children survive through the pre-school years. This is because post-neonatal mortality, which is at 3/1000, is now something of the past. Neonatal complications, other than environmental risk factors, are the major causes of death and the advanced medical technology is currently focused on these.

A report by Werner-Leonard, Andrea (1990) states that inadequate housing, lack of safety provisions and inferior health conditions contributed to the Canadian natives experiencing the highest morbidity and infant mortality rates in the country.

Benjamin (1965) contends that the most important effects of housing conditions on child mortality work through their impact on the incidence of infectious diseases; in particular, he singles out diarrhoeal diseases which he found to increase in prevalence in England and Wales with the incidence of crowding. Particularly problematical were instances where rooms are used for both day-to-day living and sleeping and where more than one family shared the same sanitary facilities. He calls attention to the difficulty of separating the effects of housing characteristics from other determinants of child mortality with which they are highly correlated: social class, social status, income, unemployment and urban-rural resistance.

Patricia A. Walter (1986) carried out a study to test the proposition that the contribution of environmental factors to the reduction of infant mortality early in the twentieth century was greater than that made by the alleviation of poverty. She found that urban development was more important than alleviation of poverty for explanation of infant mortality decline between 1895 and 1910. Urban development was a suitable index for environmental improvement. The results suggested that raising private incomes without changing environmental conditions would do little to improve mortality levels.

2.1.2 Developing countries

2.1.2a Introduction

In many poor countries 20 to 25 percent of the children die before reaching their fifth birthday, resulting in an estimated 15 million deaths annually (UNICEF, 1984). In the 1960s and 1970s there was a general optimism in the prospects of child mortality declines. The 1980s were characterized by considerable pessimism regarding prospects for further child mortality reductions. In the pessimists school of thought, three major areas of concern emerge: Firstly, the slow pace of economic development has led to a slowing pace of child mortality decline. There's only limited improvements in the Third World standards f living which cannot sustain mortality decline. Indeed of late, significant deterioration of living standards in many countries of sub-Saharan Africa and Latin America has led to worries about the possibility of an increase in child mortality rates (Cornia et al 1988).

The Structural Adjustment Programs (SAPS), planned to stabilize the dwindling economy may in itself lead to increased child mortality. Some of the measures of SAPS include reductions in government spending on social services, increase in food prices, reductions in family income, cost-sharing etc.

Secondly, instead of comprehensive, community-based primary health care, public health effort (for example, UNICEF's GOBI and WHO's KEPI programs) have narrowly focused on immunizable diseases and oral rehydration salts (ORS). This may mean that children will instead die of other non-immunizable disease and therefore less improvement in child mortality than expected.

Thirdly, the AIDS epidemic and the spread of chloroquine-resistant malaria may have a devastating effect on children in sub-Saharan Africa.

Although in the urban context decline in infant mortality has generally been faster than in other areas, in more highly educated groups (middle class sectors) the reduction tends to be increasingly slow, and in some sectors a tendency to stagnate can be observed in Peru, Honduras, Guatemala, Paraguay and Panama. Mosley suggests that the explanation for this could be the economic stagnation these privileged groups experienced, expressed via a decline in real incomes.

Poor housing condition with insufficient ventilation coupled with overcrowding were considered major causes for high measles mortality in developed countries in the nineteenth century. This applies to Africa even today as conclusions from some studies suggest that overcrowding and room density increases the risk and the severity of measles.

2.1.2b Latin America and Asia

A review of declines in age-specific mortality death rates for Mauritius between 1960 and 1977 shows that the most spectacular declines in mortality during this period occurred among persons in the younger ages and persons above forty. The factors associated with this decline were the campaign to eradicate malaria which reduced deaths due to this disease from 23.1% of total deaths in 1945 to less than 4% in 1951. During the same period the total number of deaths due too infectious and parasitic diseases had dropped from 4895 to 863. By 1977 this group of diseases contributed for only 7.1% of total deaths.

A study done by Arriaga (1981) showed that mortality decline accelerated in Chile, Colombia, Costa Rica, Malaysia, Paraguay, and Taiwan in the 1960s mainly due to a reduction of mortality from infectious, contagious and parasitic diseases. Development and public health programs are both crucial in reducing mortality; although either of them can reduce mortality independently, it would not do so efficiently.

DaVanzo and Habicht (1986) did a study of relative rules of prenatal and post-natal care, child health services, infant feeding and family planning in reducing infant and child mortality in Malaysia. They summarized that improved water supply and sanitation played a major role in the decline of infant mortality especially for babies who do not breast-feed.

Rahman et al (1988) in a prospective study of risk factors for infant mortality in Bangladesh found large effects of no toilet facilities (odds ratio=3) and for larger households vis a vis the small ones (odds ratio =1.5). Water supply was not found to be statistically significant. Potential for contamination by human waste can be indicated by type of toilet facility available (Rahman et al, 1985).

Research carried out in Bangladesh on sex differentials in childhood mortality listed fever and diarrhoea as the major causes of childhood death. It was also found that environmental factors were predominant in post-neonatal period. Included in these factors are nutritional intake, exposure to disease, breast-feeding, parental time and attention, and use of health care services.

Puffer and Serrano (1973) in their study of infant and child mortality patterns in several Latin American cities isolated diarrhoeal diseases as the leading causes of post-neonatal death. Children who were underweight at birth were found to be more vulnerable to infections resulting from poor sanitation, unsafe water and inadequate housing.
Hilderbrand et al (1985) found that among the Fulani (living in the flooded delta region) mortality in the first six months of life was 1.65 times higher than their counterparts living in the drier sahelian Seno-Mango region. The suggestion here is that place of residence has some effect on the relative risk of dying.

Robert E. Black (1983) examined a study on diarrhoeal diseases in children in Matlab, Bangladesh. The diarrhoeal pathogen is transmitted via weaning foods to young children. The foods may become faecally contaminated from impure water, unhygienic utensils, or food handling. The bacteria multiplies further when food is stored at household temperatures. He proposes intervention such as safe disposal of human faeces or protection of water supplies from contamination. But he suggests that the most promising interventions would focus on the household environment and on the immediate risks to which the child is exposed. Improvements in the quality of weaning foods from hygienic point of view and reduction in the degree of household faecal contamination by hand-washing is effective in reducing the incidence of diarrhoea.

Commenting on the future prospects of infant and child mortality in Bangladesh, M.F.Ahmed (1991) observes that a decline is unlikely due to a low level of development, where health facilities are extremely poor. The environmental conditions in Bangladesh are bad; the housing position is extremely poor and unhygienic and sanitation and water supply are inadequate. Thus diseases such as diarrhoea adversely affect the survival chances of most children.

C.G.Victora et al (1986) have reported on the effects of several socio-economic and environmental indicators on the nutritional status of a sample of 802 children aged 12-35.9 months in urban and rural areas of southern Brazil.
Environmental variables, particularly the type of housing, degree of crowding, and type of sewage disposal were also strongly associated with malnutrition. The effects of having access to piped or treated water were only apparent on stunting and wasting. Of the social variables studied, only family income and father's education level were found to show strong association with nutritional status.

In his study of neonatal mortality in Sri Lanka, Meegama (1980) examines deaths per thousand live births by type of lavatory facility in the dwelling; the lowest mortality, as expected , is associated with presence of a flush lavatory system or a water-seal system and the highest with the absence of any system. Expanding his analysis to include two- and three-way cross-classifications of sanitary facilities with husband's education and mothers' literacy,he finds lavatory facilities to have the most important impact on neonatal mortality.

2.1.2c Africa

Environmental, social and dietary factors have influenced mortality levels significantly in most African countries. Villages with polluted water supplies have poor food hygiene. Young children and mothers are greatly affected. Many families, even in the rural set-ups, live in overcrowded homes.

Studies in Tanzania (source unknown, 1976) showed that 33% of all Tanzanians were living in households with seven or more members and that 29% of these households had only one or two rooms. A majority of the population depend on rivers, lakes, streams and rain for their water supply. These factors interact to produce a pattern of ill-health which debilitates the population. Chronic and acute infections are superimposed on malnutrition and poor nutrition undermines children's resistance to diarrhoea, measles and malaria. Deaths to children under five years of age constitute a higher percentage of all deaths than their percentage in the total population. In most African countries infectious , parasitic and respiratory diseases make up almost 40% of the total deaths to children under five. A good number of children who die of respiratory tract infections have some degree of malnutrition as a contributory factor.

Conteh, David and Bauni (1990) used data from the Liberian Demographic and Health Survey, LDHS, 1986, on survival of 5,604 children and mother's household characteristics with the aim of seeking environmental risk factors of childhood mortality. The multi-variate logistic regression analysis revealed that water source from river/stream had a 30% higher risk of childhood mortality level. The effect of toilet facilities was insignificant once water supply was controlled.

Enyolu (no date) did a case study on the urban care in Nigeria and he sadly noted that the root causes of health problems in the country remain untouched as the target is focused on health personnel, health institution and health establishments. The necessary preventive health programs, and in particular the need for habitability of urban housing have been ignored. The poor majority of Nigeria's population suffer sub-standard housing, open sewers, pit latrines alongside drinking well water, and general lack of residential sanitation thus infant and child mortality is very high.

Harrington's (1974) study of West African societies views a child's chance of survival as the outcome of a series of factors governing exposure to disease and those encompassing the course and outcome of disease. These factors can be conveniently summarized as exposure and resource variables, the former group including environmental and socio-economic elements and the latter containing such components as nutritional status and access to medical care. The type of dwelling affects mortality mainly through the elements of exposure.

Rowland (1979) argues that the transmission of infectious diseases in Africa through a polluted water supply or unsanitary lavatory facilities contributes to the contamination of traditional foods. This argument is supported by the findings of Butz et al (1982) in Malaysia, that breast-feeding has a larger protective effect on infant mortality in areas where sanitary facilities are poorer.

Studying the effect of housing conditions on mortality in Bunyeshi district in Uganda, Katende (1983) has documented that poor housing condition is inversely proportional to mortality.

Regionally differentiated risk exists in Africa due to variation in disease prevalence. Farah & Preston (1982) found that the Southern regions of the Sudan have much higher levels of infant and child mortality than the northern regions, even after controlling for a variety of other factors. They argue that, "although we cannot rule out the importance of social community factors, we lean toward an explanation emphasizing the disease environment." In Kenya, for example, estimates of regional levels of life expectancy at birth and IMR vary from 39 years and 162/1000 in S. Nyanza district to 64 years and 44/1000 in Nyeri district (Kichamu,1986).

It has been suggested that region of residence is not a determinant of mortality in the same sense as other demographic or socio-economic factors (Farah and Preston, 1982). More properly , region should be viewed as accounting for the current environmental setting, and as such, it acts as a mediator for associated characteristics which may be either undefined or ill-defined.

E.Roth and B.Kurup (1990) in their study of survival patterns in Southern Sudan found that the importance of maternal literacy agrees with past studies (e.g Caldwell & McDonald, 1981) noting this variable as the single most important determinant of child mortality. What remains unclear are the exact pathways that lead from this variable to reduce child mortality. In their discussion, they suggest that this may be as diverse as the simple tasks of having children wash their hands before eating, and female autonomy in the more culturally elaborate processes, exemplified by the overriding of cultural taboos associated with traditional childhood feeding or medical practices. They noted that child mortality remains high in southern Sudan because the entrenched cultural values, crowded housing conditions, unclean drinking water and poor sanitation are more difficult to attack compared to communicable diseases which are being successfully controlled by modern medical technology.

Hilderbrand et al (1985) found that among the Fulani (living in the flooded delta region) mortality in the first six months of life was 1.65 times higher than their counterparts living in the drier sahelian Seno-Mango region. The suggestion here is that place of residence has some effect on the relative risk of dying.

2.1.2d Studies done in Kenya

A number of studies have also been done in Kenya.

Williams (1987) found a higher $_5q_0$ of 0.253 for Siaya district as compared to 0.054 for Nyeri district. Williams concluded that besides Siaya being less developed, the hostile environment favours diseases especially malaria. Epidemiologists have long recognized the influence of living conditions or the prevalence and transmission of diseases such as whooping cough and measles (Yumkella, 1988).

Ewbank, D. et al (1984) in his analysis of Kibet's research work, classifies environmental factors into two categories:

i) those related to socio-economic differences, for example high potential agricultural land per capita and urban residence.

ii) Those related to epidemiological principles for example population density and prevalence of malaria.

Ewbank et al observe that urban areas do not always have the lowest mortality rates although they generally contain the largest share of the country's well-educated, high income population and the best medical facilities. For example, the estimated IMR for Nairobi is higher than the estimate for nearby Central Province. Similarly, regression analysis of the Kenya Fertility Survey also shows that the urban areas of Nairobi and Mombasa are not substantially different from the rural areas in terms of the number of children who can die at or before age five after controlling for other characteristics of individuals.

Kibet (1981) has examined estimates of differences in child mortality indices, q(2), in the 1979 census by district and education group. In most districts, q(2) was less than half as high for children of women with a secondary education as for the children of uneducated women. A perfect example is that of South Nyanza district, which has the highest level of q(2), where women with a secondary education have a q(2) of only 43% of that reported by uneducated women. In the lowest mortality district, Nyeri, the comparable figure is 39%. Women with a secondary education living in south Nyanza district have a higher q(2), 107, than the uneducated women in Nyeri district,79; thus education is not the only important determinant of q(2). Both Mwaniki's (1983) and Kune's (1980) analysis suggest that education measures something other than income, residence or ethnic group variations in mortality.

Anker,(1977), in looking at the theoretical determinants of mortality divided them in two broad groups as:- i) Individual and household characteristics which reflect one's "standard of living. ii) Environmental factors which reflect the focus of government health policy.

Individual and household characteristics include:-

drinking water, toilet facilities, nutrition, housing, personal hygiene and preventive health, access to medical care, mother's health, sex of birth.

Environmental factors include:-

medical facilities, disease prevalence, the state of medical technology.

Anker concluded that mortality rates in Kenya were found to be significantly related to both socio-economic conditions and to macro environmental and health conditions.

Ocholla-Ayayo (1992) has suggested a modification of the Mosley and Chen framework of 1984 to include socio-cultural factors. Under this falls type of marriage, marital status, religious affiliation, form and function of traditional housing, housing condition, sanitation facilities, level of technology, forms of social organization, etc.

Ominde et al (1983) argued that diarrhoea and vomiting from malaria are the most frequent childhood disease in developing countries generally and particularly in overcrowded dwelling and areas with poor sanitation coupled with a preference for bottle feeding.

Miriam Were has aptly described the health problems in a village in western Kenya and it all points at poor environmental sanitation. Some of the things she brings out are: characteristics of a typical homestead ... surrounded with bushes and tall grass thus encouraging snakes and domestic pests and faeces because latrines are a rare structure and even where present they are not put to good use; refuse from broken pots, empty tins and dung littering the compound are good breeding spots for mosquitoes and encourage flies to multiply. Left-over food is poorly stored and left open for flies and other domestic animals to feed on and to be later eaten by the family. Both dirty and clean utensils are left to dry out in the sun on the already contaminated compound. The main source of water is rivers and streams and although knowledge of boiling water is there, firewood, which is the mode for cooking, is rather scarce.

Most studies on differential mortality have identified the risks to survival as being associated primarily with birth order, closely spaced births, geographic location and mother's education.

Nyamwange (1982), in his study aimed to describe child and infant mortality levels and differentials in Nairobi by socioeconomic, environmental and demographic aspects. In looking at the debate on technological importation vis a vis socio-economic factors, in encouraging mortality decline, he states that there are those causes of death like poor sanitation, malnutrition, diarrhoea etc. that are not amenable to medical technology. They are weakening agents leading to sickness and even death, predominantly among the poor. He found extremely large ward variations with a range of eight mortality levels between the lowest socio-economic areas and the high income wards and 20 years difference in life expectancy, despite the medical technology achievements in Nairobi city. He also found that residents of the high child mortality areas, originate from high mortality zones in the country.

Ouma (1991), aimed at determining the socioeconomic and environmental risk factors which are associated with infant and child mortality at the divisional and individual level in Siaya district. He used the 1979 census data and primary survey data. Some of the variables he analyzed are housing condition, sanitation and number of houses in the compound. His findings were that infant and child mortality rates at district level were very high ($_1q_0$ = 173/1000 and q(2) = 209/1000) resulting in a e_0 of 41 years only. There were divisional variations although mortality was still very high even at this level.

Jada (1992) in his study aimed at investigating the proposition that "there is a close association between child mortality and the level of socio-economic, socio-cultural and environmental conditions in general using KDHS,1989 data. His conclusions are yet to be summarized.

Bunyasi (1984) studied patterns of causes of deaths and seasonality of death in Kenya. The study revealed that environmental factors were responsible for both regional and seasonal variations in patterns of death. Three leading groups of diseases were: infective and parasitic diseases, diseases of respiratory system and circulatory diseases.

B. K'Oyugi (1992) carried out a study on the impact of household and community level environmental factors on infant and child mortality in rural Kenya. 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 rejected 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.

2.1.3 Summary of literature review

Thus far, environmental factors studied are housing conditions, overcrowding, urban-rural differentials, sanitation and water supply and malaria. All these, except urban-rural differentials, have been found to have a strong relationship with childhood mortality. It is on this strong basis of previous findings that the environmental risk factors used in this study have been selected, namely; household size (as a measure for overcrowding), source of water supply, type of housing and type of toilet facility. Each of these variables will be quantified so as to find out their strength in predicting child death. The interactions between these variables will also be examined.

Epidemiologic studies are getting finer into isolating the more proximate determinants of mortality. For example a more intricate examination of biological contamination of the environment by man was done by W.H.Mosley. He has developed an analytical framework that considers the social and environmental determinants of human behaviour that actually influence disease transmission and ultimately levels of mortality. The mechanism by which infectious agents are transmitted to the body are droplet, direct contact, food and water, soil, blood-feeding vector. All these are environmental conditions which may be conducive to transmission.

In conclusion, it is fit to state that mortality decline is becoming increasingly slow especially among the highly educated groups. This could be due to deteriorating economic conditions leading to high inflation, stationary incomes and therefore deteriorating environmental conditions. Some of the strategies suggested in the literature review for reducing childhood mortality are improved public health programs, water supply and sanitation and housing conditions. All these can be collectively termed as development. But development is impossible in a dwindling economy thus environmental conditions will become more grave and childhood mortality will escalate.

2.2 THEORETICAL FRAMEWORK

If facts do not fit the theory, discard the facts. <u>Meyer's Law</u>

The process of child mortality or survival within the first five years of life was modelled by Mosley and Chen (1984). This was later revised and modified by van Norren and van Vianen (1986) thus providing some systematic way of examining specific aspects of this complex process.

This model does not go beyond the level of the household. Thus to tackle this complex process of child survival at communal level, the cultural component should be blended with the environmental and demographic research approach. This will give light on how customs and tradition influence behavioral patterns related to pregnancy, delivery practices and child care. A knowledge of the epidemiology of childhood diseases will throw light on the influence of the environment at both the micro and macro levels. The demographic component gives information on both household characteristics and the demographic outcome.

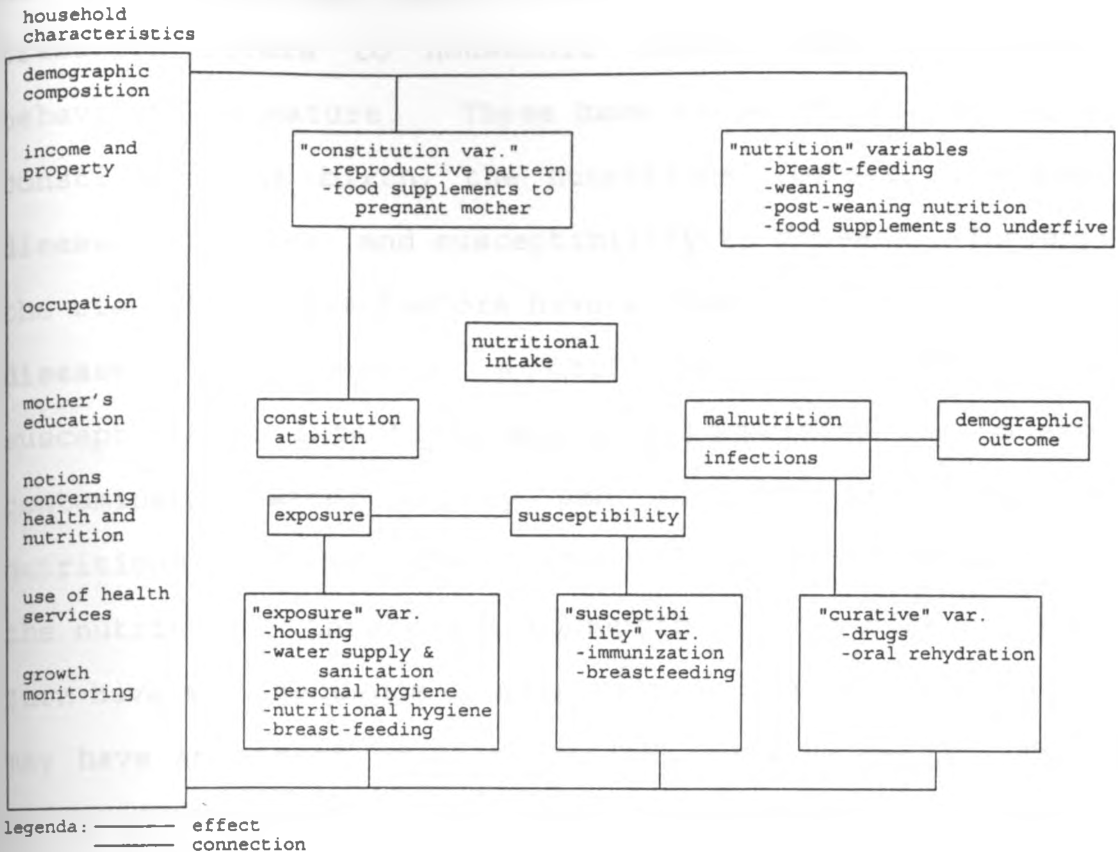
A remarkable improvement has been made by Ocholla-Ayayo (1992) in suggesting the expansion of the model by at least one more level: the anthropological component. This would help fulfil the recommendation made by van Viannen and van Norren of expanding the model.

The focus of this study is on the exposure to disease variables i.e the proximate biological determinants of mortality. Socioeconomic and cultural factors operate indirectly through the proximate factors. Many of the determinants of child mortality are:

(i) Properties of the household in which the child is located. These include levels of household income, adult literacy, health practices among members, sanitary facilities etc.

ii) Properties of the "community" of households: organization of the health care system; ecological characteristics such as climate, rainfall, presence of disease vectors; distribution of land and resources.

Figure 3a. A model of malnutrition-infections syndrome and its demographic outcome

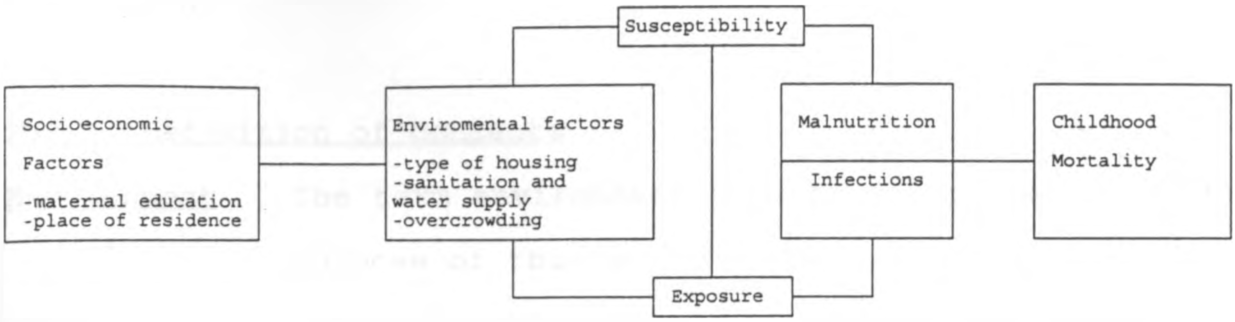


Source: van Norren,B. and H.A.W. van Vianen (1986).

As can be seen from Fig.3a, the first level of the theoretical framework refers to household characteristics and are purely behavioral in nature. These have an impact on the second level: constitution at birth, the nutritional intake, the exposure to disease variables and susceptibility to disease. The exposure to the risk of disease factors have a connection to susceptibility to disease. For example, a child who is not breastfeeding is susceptible to infections and/or malnutrition due to exposure to contaminated water supply and lack of knowledge of proper nutritional hygiene. The constitution at birth has an influence on the nutritional intake and susceptibility to disease and these in turn have a consequence on malnutrition and infections. Infections may have an effect on malnutrition and vice versa. This finally leads to the final level, the demographic outcome, which in this case is childhood mortality.

At the first level, factors like income and property, occupation, mother's education, notion about health, nutrition and use of health services are important. Apparently they indirectly control the demographic outcome through the ability or inability to suppress risk factors, such as the physical constitution at birth, the nutritional intake, exposure to infectious agents and susceptibility to infection induced by the environment.

Figure 3b. OPERATIONAL MODEL



In Fig.3b, maternal education and place of residence are the socio-economic factors considered in the operational model. These have an influence on the exposure factors i.e. type of housing, sanitation and water supply and overcrowding. These intermediate factors that have a direct influence on infections and consequently child mortality.

2.2.1 Conceptual hypothesis

Environmental risk factors such as overcrowding, source of drinking water, sanitation and type of housing are likely to have an effect on infant and child mortality.

2.2.2 Operational hypothesis

(i) Quality of floor material is a negatively related to risk of child death.

ii) Number of persons per house is positively related to childhood mortality.

iii) Contaminated water source is positively related to risk of child death.

iv) Modern toilet facility is negatively related to risk of child death.

2.2.3 Definition of concepts

Environment The term environment is a broad concept. For the purpose of this study we have referred only to the physical environment viewed at a micro-level comprising of factors like sanitation, source of water, household density and housing type.

Risk Risk implies that the probability of adverse consequences is increased by the presence of one or more characteristics or factors.

Risk factor A risk factor has been defined as any ascertainable characteristic or condition of a person or group of persons that is known to be associated with an abnormal risk of developing or being especially adversely affected by a morbid process. Thus, in our case a risk factor is simply one link (cause) or indicator of a link (signal) in a chain of associations leading to mortality.

Childhood mortality

The death of children under five years of age. Distinction is not made between deaths of children

0-1 year (infant mortality) and that of children 1-5 years (child mortality).

<u>2.2.4 Variables: the role of environmental factors</u>

Household size : Overcrowding is measured by number of persons per household . Overcrowding has long been associated with infectious diseases in epidemiologic studies. For example in Guinea-Bisau, secondary cases of measles infection were found to be more severe than index cases who contracted measles outside the household.

Source of water supply and amount of water available to a household can indicate level of contamination.

Type of housing (material of walls, roof, floor) indicates safety and protection from harsh environmental conditions.

Type of toilet facility indicates potential for contamination by human waste.

The observed relationships between these main study variables and mortality are also examined taking into account parental education, ethnic group and residence to both the probability of exposure to the risk factor and to the probability of death. Increased levels of education may alter many other features of a household's living conditions such as knowledge of proper health practices, income levels, sexual balance of power, and access to health facilities (Caldwell).

2.3 SOURCE OF DATA

Kenya DHS, 1989 was conducted between December 1988 and May 1989 by the National Council for Population and Development (NCPD) jointly with the Central Bureau of Statistics (CBS) and the Institute for Resource Development (IRD). The National Sample Survey and Evaluation Program (NASSEP) maintained by the CBS was used for sampling. The North Eastern province and four northern districts (making up only 5% of Kenya's population) were omitted. The survey favoured mainly the rural area and specifically the thirteen districts which are targets of NCPD i.e Kilifi, Machakos, Meru, Nyeri, Murang'a, Kirinyaga, Kericho, Uasin Gishu, South Nyanza, Kisii, Siaya, Kakamega and Bungoma.

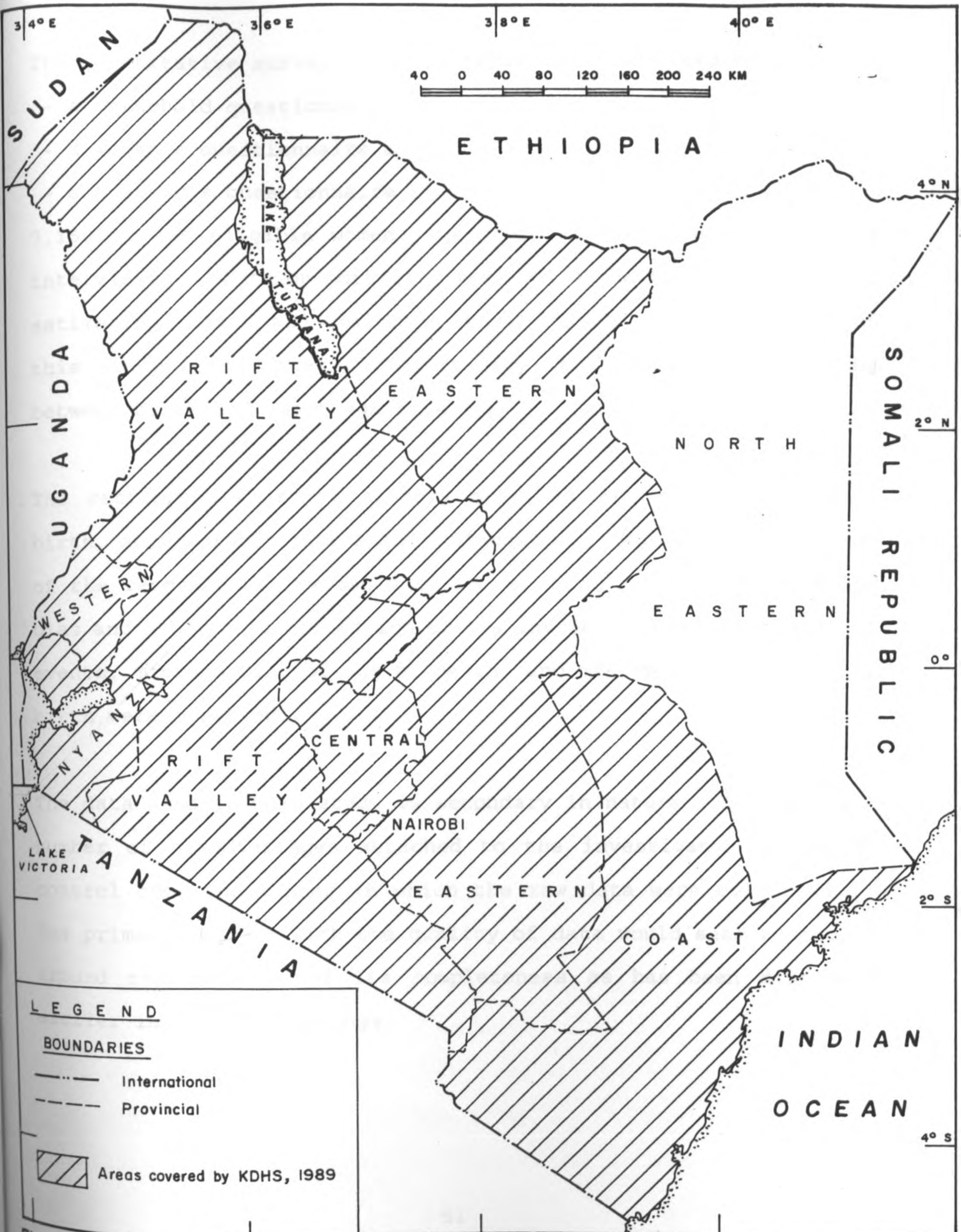


Fig. 4 : KENYA DEMOGRAPHIC AND HEALTH SURVEY BY PROVINCES

The quantitative survey utilized three questionnaires namely,

- a household questionnaire
- a woman's questionnaire and
- a husband's questionnaire

7,150 of the eligible women (age-group 15-49) were successfully interviewed. Data on mortality were collected for the purpose of estimating infant and childhood mortality rates. The focus of this study is on under five mortality: the probability of dying between birth and exact age five (${}_5q_0$).

The retrospective birth history obtained data on sex, date of birth, survivorship status and current age or age at death of each of the respondents' (women aged 15-49) live births. Truncation bias and other data collection errors involving under-reporting of events, misreporting of age at death, and misreporting of date of birth were observed.

The data used in this study is secondary in nature. There are a number of disadvantages attached to the investigator having no control over the manner in which the raw data were collected. The primary concern with the quality of data would seem to centre around the question of its completeness as has been discussed earlier in the shortcomings.

CHAPTER THREE METHODOLOGY AND RESULTS

3.1 INTRODUCTION

Trussell's technique is one of the recent methods in the estimation of child mortality after he revised Brass' method in the late 1970's (UN, 1983b, ch.III). William Brass (1964) was pioneer in developing a procedure for converting proportions dead of children ever born (CEB) reported by women aged 15-49 into estimates of the probability of dying before attaining certain exact childhood ages. An important assumption made in the development of this method is that the risk of dying of a child is a function only of the age of the child and not of other factors, such as mother's age or the child's birth order. Thus the mortality estimates based on the reports of women aged 15-19 are generally disregarded as they frequently suggest heavier child mortality and also because the numbers of children born and dead are usually small. Another assumption made here is that fertility and childhood mortality have remained constant in the recent past.

The data required are:

a) the number of children ever born, classified by five-year age group of mother;

b) the number of children dead (or number surviving) classified by five-year age group of mother;

c) the total number of women (of child-bearing age, 15-49) classified by five-year age group.

Classification of children ever born by sex is not necessary here since we are not interested in looking at sex differentials.

3.2 TRUSSELL'S TECHNIQUE

3.2.1 Computational procedure:

A detailed description of the procedure is given below using the national data from KDHS, 1989:

Table 3.1.1 FPOP(i), CEB(i), CD(i) by age-group of mother, KDHS,1989

Age-group	i	FPOP(i)	CEB(i)	CD(i)
15-19	1	1413	399	47
20-24	2	1238	1966	168
25-29	3	1268	4381	355
30-34	4	949	4737	506
35-39	5	860	5532	579
40-44	6	654	4794	550
45-49	7	431	3233	475

Step 1 **Calculation of average parity per woman.**

$$P_{(i)} = \frac{CEB_{(i)}}{FPOP_{(i)}}$$

where,

P(i) is the average parity of women of age group (i) where (i) = 1, 2, 3, 4, 5, 6, and 7 such that P(1) is the parity for women aged 15-19 and so on.

CEB(i) is the total number of children ever-born by these women aged 15-19, 20-24,...... 45-49 and FPOP(i) is the total number of women in the age group (i) irrespective of their marital status.

Thus,

$$P_{(1)} = \frac{399}{1413} = 0.282377$$

Although parity values are needed only for age groups 15-19, 20-24 25-29 and 30-34, P(i), P(2) and P(3) and P(5), respectively, all are calculated to check the quality of the basic data. The female population, FPOP(i), includes even those women who did not respond to the questions on children ever born i.e those of unstated parity. Their inclusion is based on the assumption that they are childless, an assumption supported by evidence from a large number of surveys showing that vast majority of younger women reported as being of no stated parity are, in-fact, childless.

<u>Step 2</u> **Calculation of proportion of children dead for each age group of mother.**

$$D_{(i)} = \frac{CD_{(i)}}{CEB_{(i)}}$$

where, D(i) is the proportion of children dead for women of age group (i).

CD(i) is the number of children dead reported by women in age-group i.

CEB(i) is as in step 1.

Thus,

$$D_{(1)}=\frac{47}{399}=0.117794$$

Step 3 Calculation of multipliers, K(i). Trussell's co-efficients are provided for each of the four different families of model life tables in the Coale-Demeny system. The K(i) is used as an adjustment factor to the proportion dead, D(i).

$$K_{(i)}=a_{(i)}+b_{(i)}\frac{P(1)}{P(2)}+c(i)\frac{P(2)}{P(3)}$$

where, a(i), b (i) and c(i) are the Trussell's co-efficients for estimating child mortality (see table below).

$$K(1)=1.1119+-2.987x\frac{0.282377}{1.588045}+0.8507x\frac{1.588045}{3.455047}=0.971774$$

Table 3.1.2
Co-efficients for estimation of child mortality multipliers, when data are classified by age of mother: North model.

Age-group	i	a(i)	b(i)	c(i)
15-19	1	1.1119	-2.987	0.8507
20-24	2	1.239	-0.6865	-0.2745
25-29	3	1.1884	0.0421	-0.5156
30-34	4	1.2046	0.3037	-0.5656
35-39	5	1.2586	0.4236	-0.5898
40-44	6	1.224	0.4222	-0.5456
45-49	7	1.1772	0.3486	-0.4624

Source: Manual X, 1986

Step 4 Calculation of probabilities of dying and of surviving at exact age x i.e q(x). This is the product of the reported proportions dead, D(i) and the corresponding multipliers, K(i), given as

$$q_{(x)} = K_{(i)} \cdot D_{(i)}$$

We should note that whereas i stands for age groups 1, 2, 3,4, 5, 6 and 7 of women, x stands for the ages of children who are 1, 2, 3, 5, 10, 15 and 20 years.

Table 3.1.3 Calculation of K(i) and q(x)

Age-group	i	P(i)	D(i)	K(i)	q(x)	l(x)
15-19	1	0.282377	0.117794	0.971774	0.114469	0.885531
20-24	2	1.588045	0.085452	0.990761	0.084663	0.915336
25-29	3	3.455047	0.081031	0.958900	0.077701	0.922298
30-34	4	4.991570	0.106818	0.998635	0.106672	0.893327

The probability of surviving from birth to exact age x, l(x) is then easily obtained as the complement of q(x) as follows;

$$l_{(x)} = 1.0 - q_{(x)}$$

Thus,

$$l_{(2)} = 1.0 - 0.084663 = 0.915336$$

The full results of the National and Provincial mortality estimates are thus given below:

Table 3.1.4 Mortality estimates at National and Provincial levels

mortality estimates

Region	$_1q_0$	$_4q_1$	q(2)	q(3)	q(5)
National	72.6	29.9	84.7	77.7	106.7
Nairobi	56.8	31.1	78.7	67.9	83.5
Central	31.2	10.4	19.3	42.7	63.7
Coast	106.4	77.8	146.2	94.6	240.8
Eastern	18.7	8.9	52.9	63.3	44.0
Nyanza	97.6	68.6	164.2	104.8	151.2
Rift Valley	35.8	14.2	30.0	64.5	58.8
Western	82.7	53.9	117.0	115.7	115.9

Source: Computer printout

* $_1q_0$ and $_4q_1$ are derived from the life table based on q_2, q_3 and q_5.

Mortality estimates by environmental variables were similarly calculated and can be found in the appendix.

3.2.2 Calculation of life expectancy, e_0:

This involved the construction of a life table. The l(x) value, the probability of surviving up to age (x) from birth, once obtained enabled us to determine the exact mortality levels for different values of q(x). Then using the Coale-Demeny life table we looked for the upper and lower mortality level for each l(x). Then by linear interpolation, the exact level of l(x) was calculated. The linear interpolation technique is based on getting the gradient of a line. It assumes that a straight line can be used to join the two known points without distorting the data.

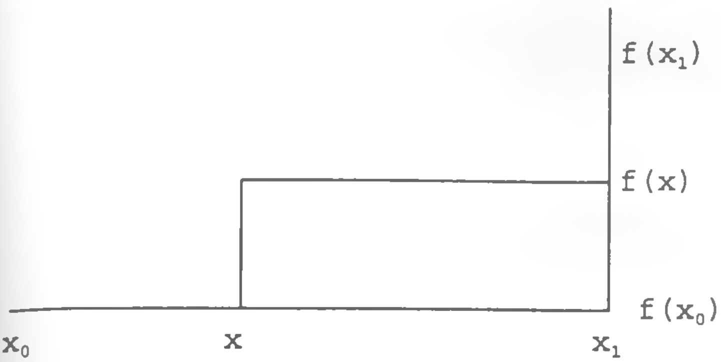


Fig. 5: Linear interpolation

Suppose that $f(x_0)$ and $f(x_1)$ refer to the probability of survival. Suppose then that $f(x)$ is a value in between which is known, Suppose also that the intermediate value (i.e the corresponding mortality level) to be estimated lies between two points whose values are known. Let the known points be x_0 and x_1, the lower and upper mortality levels, and the point to be determined as just (x). then the formula is given as follows:

$$x = x_0 + [f(x) - \frac{f(x) - f(x_0)}{f(x_1) - f(x_0)}] x [x_1 - x_0]$$

In practice, $x_1 - x_0 = 1$ since the upper and lower mortality levels are two consecutive integers.

Thus let

x_0 = level 17 $\quad$ $f(x_0) = 0.91089$

x_1 = level 18 $\quad$ $f(x_1) = 0.92386$

x = level ? $\quad$ $f(x) = 0.915336$

Applying the equation above it follows that

$$x=17+[\frac{0.915336-0.91089}{0.92386-0.91089}]x18-17$$

$$=17+\frac{0.004446}{0.01297}x1$$

$$=17+0.342791$$

$$=17.342791$$

$$x=17.3428$$

The rest of the mortality levels are similarly interpolated.

Table 3.1.5 Calculation of mortality level at national level

Age-group	q(x)	l(x)	low l(x)	upp l(x)	lower level	interpolated level
20-24	2	0.915336	0.91089	0.92386	17	17.34284
25-29	3	0.922298	0.91499	0.92898	18	18.52241
30-34	5	0.893327	0.88533	0.90252	17	17.46521

The mean mortality level is given by the average for x values 2, 3, 5. The average mortality level is:

$$\frac{(17.34284+18.52241+17.46521)}{3}=17.77682$$

Once the actual mortality level, (x), is known, the corresponding survival probability is calculated as follows:

$$f(x)=f(x_0)+\frac{x-x_0}{x_1-x_0}[f(x_1)-f(x_0)]$$

Thus let

x_0 = 17 $f(x_0)$ = 0.92764

x_1 = 18 $f(x_1)$ = 0.92737

x = 17.3 f(x) = ?

Applying the above formula we get,

$$f(x)=0.92764+[\frac{17.3-17}{18-17}][0.9273-0.92764]$$

$$=0.92764+\frac{0.3}{1}[-0.00027]$$

$$=0.92764+-0.0000926$$

$$f(x)=0.92743$$

The rest of the survival probabilities, l(x), are similarly obtained.

$_nL_x$ is the number of persons years lived between age x and x + n where:

$_1L_0 = 0.3\ l_0 + 0.7\ l_1$

$_4L_1 = 1.3\ l_1 + 2.7\ l_5$

$_5L_5 = 2.5(l_5 + l_{10})$

$_5L_{70} = 2.5(l_{70} + l_{75})$

$L_{75} = l_{75} \log_{10} l_{75}$

T_x, the total population from age x, is given by $T_x = T_{x+n} + {_nLx}$

e_x, the expectation of life at age (x), is given by

$$\frac{T_{(x)}}{L_{(x)}}$$

The life tables can be seen in the appendix.

3.3 DISCUSSION

3.3.1 Child mortality at national level

The measure of child mortality discussed in this analysis is q(5). This indicator is used in preference to other measure of child mortality because it represents cumulative mortality throughout early childhood to an age at which mortality rates are relatively low, and because it is generally well estimated by indirect techniques based on the proportion of children who have died among children ever born. No pretence is made that these sample populations are representative of the entire population in the various Provinces but tentative generalizations are made.

The under five mortality is quite high at national level and estimated at 107 per 1000 live births with a life expectancy at birth of 61 years. As is vividly displayed in table 3.1.7 mortality is highest in Coast, Nyanza and Western provinces with q(5) of 241, 151 and 116 per 1000 live births respectively. Although Eastern and Rift Valley have the lowest q(5) they have a lower life expectancy than Central province because their $_1q_0$, q(2) and q(3) are relatively much higher.

Rift Valley has $_1q_0$, q(2) and q(3) of 36, 30 and 65 per 1000 while Eastern province has q(2) and q(3) of 53 and 63 respectively. q(5) in Nairobi (84 per 1000 live births) is interestingly much higher than in Central Province with a life expectancy six years less.

A further classification of the provinces by size of child mortality is presented below using q(5) as the index.

Table 3.1.7 Classification of provinces by size of child mortality using q(5) as the index.

Category	1	11	111
q(5) per 1000 births	100+	60-95	35-60
Provinces	Western Nyanza Coast	Central Nairobi	Eastern R.Valley

The first category of Provinces consists of very high under-five mortality rates while the second category has moderate mortality rates and the third category has low mortality rates.

This tallies well with other findings that have previously shown that Western, Nyanza and Coast provinces are characterized by high mortality. Harsh environmental factors, especially the prevalence of malaria, have been attributed to high incidents of mortality in these regions (Williams, 1987). Mortality rates are also responsive to income, especially agricultural income. These three provinces are known for their poor agricultural performance and this could affect the feeding habits of mothers and their children as the availability of food variety would tend to be scarce. This then leads to poor maternal health, underweight infants at birth and subsequently poor growth which makes the child susceptible to diseases most of which are due to poor environmental conditions. Ewbank et al have shown in regression analysis that areas with high quality land tended to have lower levels of infant and child mortality.

Nairobi area would be expected to have the lowest under-five mortality since its largely urban yet its mortality rate is in the intermediate level as Kibet (1987) puts it. Ewbank et al (1984) have observed that urban areas do not always have the lowest mortality rates although they contain the largest share of the country's well-educated, high income population and the best medical facilities. May be its because the majority of urban dwellers live in the sprawling slums where water supply and sanitation, overcrowding, and housing conditions are pathetic. Also residents of high child mortality areas originate from high mortality zones in the country (Nyamwange, 1982).

An interesting observation is that although Central province has, overall,the highest life expectancy at birth (68 years) because of its low q(2), q(3) and $_4q_1$, Eastern province has the lowest under-five mortality (44 per 1000). Central province has been reported to have the lowest under-five mortality (47), followed closely by Rift Valley (51), according to estimations of mortality rates for the ten-year period preceding the survey. (KDHS, 1989 NCPD).

Life expectancy has generally improved in Kenya from 54 years (census, 1979) to 61 years and this can be attributed to the decline in Infant Mortality Rate which was at 104 in the 1979 census and is now at a low of 73 per 1000 live births. Numerous

projects going on in various parts of Kenya, especially in the high mortality zones of Western, Nyanza, Coast and Eastern provinces on maternal and child health care with an attempt to improve environmental conditions could explain the decline. This would however require an evaluation study on the impact of these programs on the improvement of environmental conditions for a more conclusive discussion.

3.3.2 Environmental factors and their influence on mortality rates

Table 3.1.8 *Mortality estimation by main floor material*

Provinces	modern		earth	
	q_5	e_0	q_5	e_0
Nairobi	0.070192	63.7	0.178232	48.2
Central	74.6	68.2	340.5	44.7
Coast	85.8	59.9	281.6	49.1
Eastern	0.026355	69.7	0.055133	64.2
Nyanza	0.093914	62.7	0.161484	52.2
R.Valley	0.071526	65.6	0.109101	58.8
Western	0.053576	63.0	0.121153	56.3
National	100.1 62.8		124.8 52.8	

Source: computer printout

Child mortality by main floor material used to construct the respondent's dwelling place was estimated . The floors were classified into two types namely, modern which includes tiles, wood, vinyl, cement etc., and earth and others which may be plastered with cow-dung and so on.

From the table 3.1.8, it is clear that under-five mortality is very high for children whose mothers have earth as the main floor material and in almost all provinces the difference is more than 50%. It also follows that life expectancy at birth is highest amongst children whose mothers have modern floor material. It is, however, remarkable that children of mothers with earth floors in Eastern Province experience a much lower under-five mortality than those of mothers with modern floors in all the other provinces except Western. This reflects the general low rate of q(x) in Eastern Province. Those whose mothers have earth floors have a q(5) of 55/1000 which constitutes 53% more child mortality in the Province. It is difficult to explain the outcome of these results as they did not turn out as (we) expected given that Eastern Province is frequently drought stricken and with harsh environmental conditions.

Central Province portrays the widest gap of 78% under-five mortality between mothers of the two contrasting categories. We ought to bear in mind it is almost impossible to draw a clear-cut line between socio-economic and environmental variables. The condition of the environment may be confounded by socio-economic circumstances such that if a society has great variations in socio-economic differences this will be clearly reflected in environmental variations and consequently large differences in under-five mortality will be observed. This could be the case not only in Central Province but in all the other Provinces considered. It so happens that the population that is economically weak find themselves settling in environmentally poor areas where the climate is relatively hotter and with more mosquitoes, poorly drained soils, poor sanitation, over-crowded, sub-standard housing structures, invaded by industries and so on. On the other hand, the economically advantaged population tends to settle in cooler and quieter parts with less mosquitoes, better drained soils and good housing and sanitation. Thus those living in earth houses must suffer very harsh environmental conditions.

Nationally, the under-five mortality of those living in earth houses over those in modern is 20% greater.

Table 3.1.9 ***Mortality estimation by number of household members***

Provinces	≤ 4 members		≤ 9 members		≥ 10 members	
	q_5	e_0	q_5	e_0	q_5	e_0
Nairobi	153.7	58.2	-	-	109.6	56.2
Central	77.0	66.2	-	-	166.2	58.0
Coast	391.0	35.6	-	-	245.3	47.4
Eastern	145.3	64.7	74.6	64.6	77.0	62.8
Nyanza	155.1	57.1	116.9	57.5	106.5	50.7
R.Valley	120.3	59.2	137.6	55.2	163.8	53.5
Western	70.8	60.1	110.2	59.2	125.6	55.2
National	95.1	60.8	90.1	60.4	134.0	54.8

Source: computer printout
- missing

Child mortality by number of household members was estimated and the variable was split into three groups: under four household members, under nine household members and above ten members. There was no sufficient data to estimate rates for the 'under nine household members' for Nairobi, Central and Coast Provinces.

Generally, the fewer the number of household members the higher the life expectancy at birth in all provinces. In Central province, for instance, large households of more than ten members contribute 54% more child mortality than is experienced in the other two groups. However, the under-five mortality shows no definite pattern as is evident from the inconsistency in Nairobi, Coast, Eastern and Nyanza provinces which depict an inverse relationship between number of household members and child mortality while Central, Rift

Valley and Western show a converse relationship. This is a difficult phenomenon to explain as the expected trend would have been a converse relationship where the under-five mortality increases with number of household members. A plausible explanation would be that the respondents with large households may have experienced hardly any fertility and thus their mortality tends to be low. It should be noted that these household members need not be their siblings and in this case are probably extended relations. We cannot also rule out the more obvious possibility of a faulty data set as has been afore-mentioned. Nationally, the q(5) of those with large households of over ten members over those with small households with four or less members is 29%. In the towns overcrowding tends to be common due to the small space but in the rural areas this is not the case as custom dictates separation of members such that boys stay in their various huts and so on.

Table 3.1.10 ***Mortality estimation by source of drinking water***

Provinces	piped in to house		public tap		river		well		lake & pond		rainwater	
	q_5	e_0	q_5	e_0	q_5	e_0	q_5	e_0	q_5	e_0	q_5	e_0
Nairobi	72.2	63.9	101.7	59.8	-	-	-	-	-	-	-	-
Central	71.4	65.8	142.2	58.5	146.1	57.9	-	-	-	-	-	-
Coast	119.6	57.7	143.7	57.2	209.8	51.6	86.7	53.9	398.8	45.2	-	-
Eastern	95.0	62.1	126.9	58.6	129.9	56.9	95.5	59.0	-	-	-	-
Nyanza	100.7	57.7	125.9	56.3	208.2	43.8	126.8	54.7	215.3	43.8	64.2	54.7
R.Valley	40.1	67.9	72.9	65.3	106.5	60.2	77.3	62.2	109.8	60.2	96.7	62.2
Western	18.9	65.7	111.7	55.4	114.2	54.8	143.5	59.4	156.4	53.0	-	
National	78.2	63.7	106.1	54.6	96.8	57.8	75.6	62.2	425.9	30.0	126.9	65.2

Source: computer printout
- missing

This was classified according to the six different sources namely, water piped into the house, public tap, river, well, lake and pond and rainwater. Rainwater had insufficient data for most provinces and this would be attributed partly to the fact that it is an unreliable source of water for most of the year. Lake & pond were merged as they both tend to be stagnant therefore of same quality. In general, users of water piped into house appear to have the least under-five mortality and the highest life expectancy followed by users of public tap, well, rainwater, river and lastly, lake & pond.

A substantial difference of about 26% can be observed in the mortality between users of water piped into house and public tap and a four years' difference in life expectancy. For example, in Western province children of public tap users exceed mortality by 83% with a 10 year's difference in life expectancy. Public tap is not necessarily near the house and therefore the distance will determine the number of times water can be fetched on a daily basis. Nairobi in particular has very unhygienic public tap areas which are multi-purposely used for bathing children, washing dishes, fetching water etc. and the areas are always slimy green with food particles and faeces lying around. These are some of the useful but missing quantitative survey details crucial to exposition of analysis.

Well water is very good for drinking as long as it is not salty and it is far healthier than rainwater which lacks in the mineral salts obtained from the rocks. Wells must be covered to protect them from dirt. In most cases this is not practiced and so the well water gets contaminated. River water is exposed to adulteration in terms of laundry, bathing, urination, faecal contamination, industrial waste and so forth. This makes it unfit for drinking unless treated prior, a hygienic practice that is rarely carried out. Lake & pond water is infamous for its stagnant and contaminated water and requires thorough treatment before it can be fit for consumption. It is not surprising therefore that children of users of these waters have an 81% higher mortality over those using water piped into house with half the life expectancy.

Table 3.1.11 ***Mortality estimation by type of toilet facility***

Provinces	flush toilet		pit latrine		no toilet		bucket & others	
	q_5	e_0	q_5	e_0	q_5	e_0	q_5	e_0
Nairobi	74.5 64.8		137.0	58.0	-	-	-	-
Central	19.5 70.3		129.4	58.1	-	-	-	-
Coast	84.3 56.9		176.2	55.1	-	-	-	-
Eastern	-	-	83.1	59.0	138.6	52.7	-	-
Nyanza	95.6 58.8		133.3	52.5	223.5	46.0	-	-
R.Valley	31.5 64.3		60.0	64.3	149.5	58.0	-	-
Western	53.6 63.5		119.4	54.8	158.4	48.7	-	-
National	62.8 61.2		78.6	60.0	204.3	44.1	346.6	49.6

Source: computer printout
- missing

Mortality estimates for those with no toilet, flash toilet, pit latrine and bucket & others were obtained. At the provincial level, data was insufficient for calculating child mortality and life expectancy at birth of children of mothers using bucket & other facilities. However, child mortality and life expectancy at national level is estimated as 347% and 50 years respectively. Nairobi, Central and Coast provinces did not have adequate data to enable estimation of rates.

Child mortality seems lowest for children of mothers who have a flush toilet, i.e. 63/1000 live births followed by those with pit latrine, no toilet and lastly bucket facility. At the national level, users of pit latrine have a 20% mortality above that experienced by users flush toilet. The widest gap is observed in Central province where mortality for pit latrine users is 84% higher than users of flush toilet. One could argue that the majority of residents in the province have flush toilet and generally good living conditions such that those with pit latrine have generally poorer living conditions and consequently poorer environmental conditions. As can be seen, in Nyanza province where mortality is highest the difference between mortality of pit latrine users and flush toilet users is only 28%. Children of mothers with no toilet have over 40% mortality over those of mothers with pit latrines.

We cannot over-emphasize the need for a pit latrine in the home compound. They are easy to use and keep clean and are far more hygienic than buckets which have an appallingly high q(5) of 347/1000. This rate is higher than that of the population without toilet at all.

Table 3.1.12 ***MORTALITY ESTIMATION BY AGE CHILDREN USE ADULT TOILET***

Provinces	under 4 years		above 5 years	
	q(5)	e_0	q(5)	e_0
Nairobi	78.4	60.1	76.9	62.1
Central	114.3	62.3	76.4	66.3
Coast	151.2	59.0	121.6	61.1
Eastern	92.5	59.0	40.3	61.1
Nyanza	117.7	52.5	133.5	54.7
R. Valley	74.4	62.2	61.0	64.3
Western	118.4	54.8	56.6	56.2
National	166.5	49.2	110.4	56.0

Source: computer printout
- missing

The above table suggests a higher child mortality for children using adult toilet when aged under 4 years than those using adult toilet above 5 years. The life expectancy also shows at least 2 years difference between the two groups of children. In Eastern and Western provinces children using adult toilet under 4 years of age have over 50% more mortality over those using adult toilet above 5 years of age.

The age at which children use adult toilet may not be significant where sanitary conditions are decent. More often than not, this is not the case and therefore it becomes a big risk if a young child under 4 years of age is left to attend the adult toilet be it a flush toilet, pit latrine and worse still a bucket!

3.4 VARIATION OF RATES BY PROVINCE

Nairobi Province: Earth houses are a high mortality risk in the city (178/1000) with a low life expectancy at birth of 48 years. Pit latrines are a high risk too. These are certainly respondents living in slum areas where the general environment is pathetic. However, the Infant Mortality Rate is moderate, an indication that babies who are breast-feeding exclusively are hardly affected by environmental adversities. This is because the breast milk is fed to the baby directly unlike the substitute milk and supplementary foods which require some preparation. This makes the latter to be at high risk of contamination through the water and the utensils being used.

Table 3.1.13 ***Mortality estimates by environmental factors by province***

NAIROBI — Mortality rates

Characteristics	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	50.0	25.6	68.4	48.2	70.2	63.7
-earth	127.2	100.4	179.5	201.1	178.2	48.2
2. No. hsehold members						
-≤ 4 members	75.2	47.1	99.7	70.9	153.7	58.2
-≥ 5 members	85.0	56.2	129.7	118.5	109.6	56.2
3. Source of drinking water						
-piped into house	48.7	24.6	79.1	42.8	72.2	63.9
-public tap	67.5	40.3	93.4	84.0	101.7	59.8
4. Type of toilet facility						
-flush toilet	45.1	21.6	47.2	59.2	74.8	64.8
pit latrine	76.4	48.2	112.7	75.4	137.0	58.0
5. Age children use adult toilet						
-under 4 years	66.5	39.5	115.5	88.0	78.4	60.1
-above 5 years	57.1	31.4	62.9	73.3	76.9	62.1

Source: computer printout

* *$_1q_0$ and $_4q_0$ are derived from the life table based on q_2, q_3 and q_5.*

<u>Central Province:</u> The province appears to have a generally low child mortality and the highest life expectancy in the country of 70 years among children of mothers with flush toilet. There are , however, some high peaks as seen among those living in earth houses who have an under-five mortality of 240/1000. This is extremely high for a moderately low mortality area. Overcrowded households, river and public tap users also show a high risk.

Table 3.1.14 ***Mortality estimates by environmental factors by province***

Central — mortality rates

characteristics	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	31.2	10.4	20.0	33.6	74.6	68.2
-earth	148.6	120.3	82.1	299.9	240.5	44.7
2. No. of hsehold members						
≤ 4 members	39.6	17.3	33.7	50.0	77.0	66.2
≥ 5 members	76.3	48.1	51.5	124.6	166.2	58.0
3. Source of drinking water						
-piped into house	40.9	18.3	33.9	59.3	71.4	65.8
-public tap	73.8	45.8	82.4	91.7	142.2	58.5
-river	77.0	48.7	82.0	103.2	146.1	57.9
4. Type of toilet facility						
-flash toilet	23.3	5.8	30.8	31.7	19.5	70.3
-pit latrine	75.7	47.6	50.4	170.4	129.4	58.1
5. Age children use adult toilet						
-under 4 years	56.4	30.9	50.4	100.5	114.3	62.3
-above 5 years	38.9	16.6	22.1	86.3	76.4	66.3

Source: computer printout

** $_1q_0$ and $_4q_0$ are derived from the life table based on q_2, q_3 and q_5.*

Coast Province: Child mortality at the Coast assumes very high rates not only by environmental factors but generally too. The environmental factors only seem to suggest where the risk is highest. For example, although only a small population in the province use lake as their source of drinking water, their mortality risk is greatest (299/1000). The probability of dying is also high among those using river water (210/1000) and those living in earth houses (282/1000). The life expectancy is at a low of 45 years and is to be found among children of lake users.

Table 3.1.15 ***Mortality estimates by environmental factors by province***

COAST — mortality rates

Characteristics	${}_1q_0$	${}_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	67.5	40.3	110.1	80.8	85.8	59.9
-earth	122.4	95.3	182.0	99.2	281.6	49.1
2. Source of drinking water						
-piped into house	77.8	49.5	176.6	40.8	119.6	57.7
-public tap	80.0	51.4	124.0	88.5	143.7	57.2
-river	108.4	80.0	155.5	115.9	209.8	51.6
-well	96.7	67.7	170.7	154.9	86.7	53.9
-lake	145.6	117.6	205.5	116.4	298.8	45.2
3. Age children use adult						
toilet	71.6	43.9	142.6	104.3	151.2	59.0
-under 4 years	61.9	35.5	29.0	85.7	121.6	61.1
-above 5 years						
4. Type of toilet facility						
-flush toilet	81.7	53.0	187.2	50.9	84.3	56.9
-pit latrine	92.2	63.1	133.4	71.0	176.2	55.1
5. No. of hsehold members						35.6
≤ 4 members	216.0	182.8	330.4	235.1	291.0	47.4
≥ 5 members	132.0	104.9	230.2	134.9	245.3	

Source: computer printout

* *${}_1q_0$ and ${}_4q_1$ are derived from the life table based on q_2, q_3 and q_5.*

It is noteworthy that although Mombasa is the second largest town after
Nairobi, a good number of houses are constructed using low quality materials and mud floors are common. Most households occupy one room and a large element of crowding is present due to the nature of the 'Swahili' house design. These conditions are not conducive to child survival.

The highest life expectancy at birth is 61 years among children of mothers using adult toilet above 5 years of age.

Table 3.1.16 ***Mortality estimates by environmental factors by province***

EASTERN — Mortality rates

	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	25.2	6.6	22.7	43.3	26.4	69.7
-earth	48.1	24.0	62.4	71.9	55.1	64.2
2. No. of hsehold members						
≤ 4 members	45.5	21.9	37.5	25.1	145.3	64.7
≤ 9 members	46.1	22.4	64.6	56.8	74.6	64.6
≥ 10 members	54.0	28.9	74.7	65.8	77.0	62.8
3. Source of drinking water						
-piped into house	57.2	31.5	68.5	71.3	95.0	62.1
-public tap	73.5	45.6	93.5	90.1	126.9	58.6
-well	71.4	43.7	127.4	73.0	95.5	59.0
-river	81.5	52.8	115.3	102.3	129.9	56.9
4. Age children use adult toilet						
-under 4 years	71.4	43.7	103.2	74.4	92.5	59.0
-above 5 years	61.7	35.3	98.3	72.5	40.3	61.1
5. Type of toilet facility						
-no toilet	102.8	73.9	176.2	121.7	138.6	52.7
-pit latrine	71.4	43.7	100.0	81.3	83.1	59.0

Source: computer printout

* *$_1q_0$ and $_4q_1$ are derived from the life table based on q_2, q_3 and q_5.*

Eastern Province: Lack of a toilet facility and use of river as a major source of drinking water causes high mortality in the province of up to 139/1000 live births. This is a steep rise indicating that these factors have a great influence on mortality of children in the Province.

There is sufficient evidence that parts of Eastern Province are well-endowed with safe water sources in both the dry and wet seasons and that pit latrines are largely used. In these areas, therefore water-borne and related diseases are very rare. It is possible then that the data gathering was more biased towards these favourable parts of the province. However, it is still the small percentage of the population which has no toilet facilities and use contaminated river water that is causing the high child mortality and is therefore our major concern.

Table 3.1.17 ***Mortality estimates by environmental factors by province***

NYANZA — mortality rates

	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	54.4	29.2	48.8	83.8	93.9	62.7
-earth	105.2	76.6	192.1	104.5	161.5	52.2
2. No. of hsehold material						
-≤ 4 members	80.6	52.0	111.0	81.3	155.1	57.1
-≤ 9 members	79.0	50.6	117.0	98.0	116.9	57.5
-≥ 10 members	113.3	85.4	190.5	144.0	106.5	50.7
3. Source of drinking water						
-piped into house	78.0	49.6	159.3	67.9	100.7	57.7
-public tap	84.7	55.9	124.2	108.6	125.9	56.3
-well	92.5	63.0	179.4	50.3	126.8	54.7
-river	153.8	125.6	198.7	165.9	208.2	43.8
-lake	153.8	125.6	199.0	176.5	215.3	43.8
rainwater	92.5	63.0	165.7	93.2	64.2	54.7
4. Type of toilet facility						
-no toilet	139.7	114.2	174.5	125.2	223.5	46.0
-pit latrine	103.3	74.1	157.9	97.5	133.3	52.5
-flush toilet	71.8	43.9	78.4	59.9	95.6	58.8
5. Age children use toilet						
-under 4 years	103.3	74.1	126.0	111.8	117.7	52.5
-above 5 years	92.5	63.0	119.4	91.9	133.5	54.7

Source: computer printout

* *$_1q_0$ and $_4q_1$ are derived from the life table based on q_2, q_3 and q_5.*

Nyanza Province: The general mortality situation by all environmental factors is appallingly high and at over 100/1000 live births. The gravest of these is among children of mothers using either river or lake as source of drinking water, and those with no toilet facility. The lowest life expectancy of 44 years and 46 years is seen among the same group of children.

It has been shown that a large percentage of households in this province use contaminated water from the river or lake for drinking and that a good number have no toilet facility. These two are the gravest environmental problems as they cause the high incidents of water-related diseases such as vomiting, diarrhoea and malaria.

Table 3.1.18 ***Mortality estimates by environmental factors by province***

Rift Valley — mortality rates

	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	41.9	19.0	49.0	45.5	71.5	65.6
-earth	72.5	44.6	101.9	91.4	109.1	58.8
2. No. of hsehold members						
≤ 4 members	70.4	42.9	51.9	134.7	120.3	59.2
≤ 9 members	89.9	60.9	156.0	90.3	137.6	55.2
≥ 10 members	100.8	71.9	124.6	150.4	163.8	53.5
3. Source of drinking water						
-piped into house	32.4	11.4	27.8	55.6	40.1	67.9
-public tap	43.5	20.3	54.4	45.4	72.9	65.3
-well	56.7	31.1	38.1	126.8	77.3	62.2
-river	66.2	39.1	96.8	68.1	106.5	60.2
-lake	66.2	39.1	133.3	55.5	109.8	60.2
-rainwater	56.7	31.1	56.9	68.6	96.7	62.2
4. Type of toilet facility						
-no toilet	76.1	47.9	84.8	104.8	149.5	58.0
-pit latrine	47.7	23.7	78.8	70.4	60.0	64.3
flush toilet	47.7	23.7	45.4	90.2	31.5	64.3
5. Age children use adult toilet						
-under 4 years	56.7	31.1	74.8	72.5	74.4	62.2
-above 5 years	47.7	23.7	71.9	75.5	61.0	64.3

Source: computer printout

* *$_1q_0$ and $_4q_1$ are derived from the life table based on q_2, q_3 and q_5.*

Rift Valley: The under-five mortality by environmental factors scales from high and skews towards medium level. Overcrowded households appear to have the highest child mortality, 164/1000 followed by those with no toilet facility 150/1000 with a life expectancy of 54 and 58 years respectively. Lake and river waters also suggest a high child mortality, a pattern that was observed in Western Kenya.

A large mortality gap between children of mothers owning modern houses and those owning earth houses can be observed, 72/1000 and 109/1000 respectively. An appreciable number of women respondents own earth houses and have one of the highest child mortality in the province. Another notable thing is that a large number of women respondents reported to have no form of toilet facility. This is the target group as their environmental status is very pathetic thus contributing to a high mortality in the province.

Table 3.1.19 *Mortality estimates by environmental factors by province*

WESTERN — mortality rates

	$_1q_0$	$_4q_1$	q_2	q_3	q_5	e_0
1. Main floor material						
-modern	53.0	28.0	91.2	65.1	53.6	63.0
-earth	84.7	55.8	116.5	120.8	121.2	56.3
2. No. of hsehold members						
≤ 4 members	66.3	39.3	99.7	100.4	70.8	60.1
≤ 9 members	70.5	42.9	77.4	109.1	110.2	59.2
≥ 10 members	90.3	61.3	131.9	126.4	125.6	55.2
3. Source of drinking water						
-piped into house	41.2	18.5	57.0	89.1	18.9	65.7
-public tap	36.8	98.9	152.9	83.6	111.7	55.4
-well	70.0	42.5	117.5	41.7	143.5	59.4
-river	79.1	73.0	126.8	135.9	114.2	54.8
-lake	101.2	72.3	153.2	131.2	156.4	53.0
4. Type of toilet facility						
-no toilet	124.4	97.4	169.7	166.1	158.4	48.7
-pit latrine	79.1	73.0	109.2	129.1	119.4	54.8
-flush toilet	51.2	26.6	78.8	34.0	53.6	63.5
5. Age children use adult toilet						
under 4 years	79.1	73.0	111.9	111.5	118.4	54.8
above 5 years	44.9	86.4	108.2	101.1	56.6	56.2

Source: computer printout

* $_1q_0$ and $_4q_1$ are derived from the life table based on q_2, q_3 and q_5.

Western Province: The risk of dying escalates among lake users and those with no toilet facility, 156/1000 and 158/1000 respectively. The life expectancy of children of mothers with no toilet facilities is estimated at 49 years, the lowest among all the variables considered. Toilet facility is very crucial in a home as it helps prevent littering of the compound with stool and also discourages bushes around the homestead which are otherwise used as relieve spots.

High mortality can also be observed among children of mothers owning earth houses (121/1000) compared to those owning modern houses (54/1000). It is also likely that the same population living in earth houses is the same without toilet facilities. Improved environmental conditions of basic needs are mandatory if expectation of life is to be elevated.

3.5 SUMMARY AND CONCLUSIONS

Under-five mortality is still very high at both the national (107) and provincial levels. This is largely reflected by environmental factors at household level as portrayed by mortality indices for the various environmental variables i.e. housing condition, water supply and sanitation and number of household members.

Lack of toilet facility, use of bucket, lake and pond, public tap and usage of adult toilet facilities by children aged under 4 years are the environmental indicators of high under-five mortality rates.

Water is a basic need for human survival and should be within reach of the households so as to improve their well-being and create more time and energy for family members to involve themselves with other productive and recreative activities. Source of drinking water may be unsafe as is the case for a majority of the population but the most important thing is whether the water is treated. For example in Nyanza Province, the major sources of water are rivers, lakes, ponds and dams in all the seasons of the year. A Household Welfare Monitoring and Evaluation Survey of South Nyanza district (1991) indicates that only 12% of the population draw water from safe sources. Yet of the 88% who draw water from unsafe sources, only 28% of the households treat it for drinking. Contaminated water is lethal to the health of human beings and more so children who have already started weaning. Diarrhoea is a water-borne disease and its likely that those who suffer from diarrhoea use untreated water from unsafe water sources.

Wells should be advocated especially for use in the dry seasons and should be dug by experts so that the source is not contaminated by the pit latrine.

Housing is also a major basic need necessary for human survival. A good house not only gives security and comfort to the members but also provides protection against harsh environmental conditions such as cold, wind, hot sun, and so on. The floor should be well-plastered with easy-to-clean material as this is where the child spends most of his/her day hours playing. Earth floors are difficult to keep clean and tend to harbour germs.

Adequate sanitation is an important strategy for the reduction of environmental pollution. Clean water and sanitation facilities when available contribute greatly to the achievement of environmental health care.

Table 3.1.20 *MORTALITY ESTIMATION AT NATIONAL LEVEL BY ENVIRONMENTAL FACTORS*

Mortality rates

characteristics	${}_1q_0$	${}_4q_1$	q_2	q_3	q_5	e_0
1. MAIN FLOOR MATERIAL						
-Modern	54.1	29.0	47.6	78.6	100.1	62.8
-Earth	102.4	73.6	193.3	121.9	124.8	52.8
2. No. OF HSEHOLD MEMBERS						
≤ 4 members	63.0	36.4	79.2	85.2	95.1	60.8
≤ 9 members	65.1	38.3	96.8	80.3	90.1	60.4
≥ 10 members	76.6	74.6	90.1	167.2	134.0	54.8
3. SOURCE OF DRINKING WATER						
-Piped into house	49.9	25.6	59.5	63.6	78.2	63.7
-public tap	68.7	41.3	74.5	100.9	106.1	59.6
-river	77.3	49.0	153.9	72.5	96.8	57.8
-well	56.9	31.3	81.8	72.1	75.6	62.2
-lake & pond	270.0	232.9	396.5	341.0	425.9	30.0
-rain water	73.8	45.9	92.1	93.0	126.9	65.2
4. TYPE OF TOILET FACILITY						
-no toilet	153.1	124.5	267.2	202.5	204.3	44.1
-flush toilet	61.4	35.1	85.0	69.5	62.8	61.2
-pit latrine	66.7	39.6	119.0	75.5	78.6	60.0
-bucket & others	119.5	92.2	54.3	200.3	346.6	49.6
5. AGE CHILDREN USE TOILET						
-under 4 years	121.4	94.2	224.3	141.2	166.5	49.2
-above 5 years	83.2	54.5	133.6	105.6	110.4	56.0

Source: computer printout

* ${}_1q_0$ and ${}_4q_1$ are derived from the life table based on q_2, q_3 and q_5.

CHAPTER 4 RESULTS YIELDED BY THE LOGISTIC REGRESSION ANALYSIS

4.1 INTRODUCTION

This analysis is complementary to the demographic technique discussed in the previous chapter. The information used in this analysis includes those children who were born during the preceding five years to mothers interviewed in the survey. This helps us focus on recently born children and therefore avoid errors caused by memory lapse. At the same time, it helps in supporting our assumption that the household environmental characteristics observed at the time of interview are close to those existing at the time mortality occurred. However, it is further emphasized that these results should be treated with caution as the different estimates may be subject to over or under estimation for the reasons discussed in Chapter 1.

We shall first attempt to explain the methodology of the study after which the tables of results shall be discussed with an attempt to sum up with some logical conclusions.

4.2 METHODOLOGY OF THE STUDY

The methodology was adapted so as to suit the objective of this study which is to quantify the strength of the 'exposure to the risk factors' for predicting child death.

Logistic regression analysis is a special case of ordinary multiple least squares regression in that the dependent variable becomes dichotomous. Other properties of the regression model remain the same.

4.2.1 Independent variables

These are the exposure to the risk variables of those children still alive at the time of their mothers' interview compared to those who have died. The living conditions at the time of the survey were used as measures of exposure status to environmental and household risk factors. The risk factors identifiable in the data are thus,

1. Source of drinking water: Piped into house (PHOUSE) - this was the reference category.
   Public tap (PUBTAP)
   Well with/without handpump (WELL)
   River
   Lake, pond (LAKE)
   Rainwater, other (RAIN)

2. Type of toilet facility: No facilities (T_0)
   Flush toilet (T_1) - this was the reference category.

   Pit latrine (T_3)
   Bucket, other (T_5)

3. Main floor material: Modern - parquet, vinyl, tiles, wood planks, cement (F1) - this was the reference category.
   Earth - earth, other (F6)

4. Number of household members (as a measure for overcrowding):
   Less than 5 members (LT5) - this was the reference category.
   Less than 10 members (LT10)
   More than 10 members (GT10)

5. Age children use adult toilet: Less than 5 years (LT5Y)
   Above 5 years (GT5Y)

The study takes into account possible confounding variables known to have an influence on child mortality such as maternal education, region of residence (i.e. Province), and urban/rural residence; these were controlled. However, when we controlled for region of residence there was no reasonable output from the results in almost all the Provinces so these were disregarded.

4.2.2 DEPENDENT VARIABLE:

The survival status of the child at the time of the survey (i.e. alive or dead) was the dependent variable.

4.2.3 The logistic regression model

In Logistic Regression you directly estimate the probability of an event occurring. For the case of a single independent variable, the Logistic Regression model can be written as

$$Prob(event) = \frac{e^{B_0+B_1X}}{1+e^{B_0+B_1X}}$$

or equivalently

$$Prob(event) = \frac{1}{1+e^{-(B_0+B_1X)}}$$

where, B_0 and B_1 are coefficients estimated from the data, X is the independent variable, and e is the base of the natural logarithms, approximately 2.718.

For more than one independent variable the model can be written as

$$Prob(event)=\frac{e^{z}}{1+e^{z}}$$

or equivalently

$$Prob(event)=\frac{1}{1+e^{-z}}$$

where Z is the linear combination

$$Z=B_0+B_1X_1+B_2X_2+\cdots+B_pX_p$$

Logistic Regression can measure the risk associated with a particular variable. This is approximated by

$$\frac{Prob(event)}{1-Prob(event)}=e^{z}$$

This is usually odds ratio which is used as the approximate value for Relative Risk. Therefore in the table below exp(B) are the approximate Relative Risk values of the corresponding variables when compared to the reference category.

Model 1a Parameter estimates for the Logistic Regression Model

Variable	B	S.E.	Sig.	R	exp(B)
LAKE	.7010	.3459	0.0427	0.0538	2.0157
LT10	-1.2853	.2753	0.0000	-0.1634	0.2766
GT10	-0.8795	.3177	0.0056	-0.0874	0.4150
CONSTANT	-3.5765	.1935	0.0000		

For example, model 1a presents estimated coefficients (under column heading B) and related statistics from the Logistic Regression model that predicts the risk of childhood mortality from a constant by exposure factors, Lake LT10, GT10.

The Logistic Regression equation for the risk of mortality can be written as

$$Prob(mortality) = \frac{1}{1+e^{-z}}$$

where

$$Z = -3.5765 - 0.8795\ (GT10) - 1.2853\ (LT10) + 0.7010\ (LAKE)$$

The probability of the event not occurring is estimated as

Prob (no event) = 1 - Prob (event)

4.2.4 The dummy variables

A dummy variable is any variable in an equation that takes on finite number of values for the purpose of identifying different categories of a nominal variable (Kleibaum and Kupper 1978). In general multiple regression requires that variables are measured on interval or ratio scale and the relationship among the variables are linear and additive. Where this is not the case, and categorical variables have to be used, then they have to be transformed into dummy variables. For example, source of drinking water considered here has to be transformed into dummy variables while number of household members can be introduced into the regression analysis without using dummy variables.

4.3 LOGISTIC REGRESSION RESULTS

The Odds Ratios can be interpreted as indicating the risk of a child death relative to the reference category of the variable, when all other factors included in the model are held constant. In each of the risk variables, we identified a reference category and instructed the computer to compute the relative risk between that reference category and the other categories. For example, source of drinking water is a risk variable affecting survival status of children. A reference category chosen was "water piped into house". If the odds ratio (e^B) for the variable lake is 2.0157 (see model 1a in table), then the lake is associated with twice as much risk as water piped into the house with respect to child survival.

Model 1b. General model

Variable	*B*	*S.E.*	*Sig.*	*R*	*exp(B)*
LT10	*-0.8918*	*.2509*	*0.0004*	*-.1197*	*.4099*
CONSTANT	*-3.8952*	*.1513*	*0.0000*		
LT10	*-1.2753*	*.2751*	*0.0000*	*-0.1621*	*.2793*
GT10	*-0.8463*	*.3167*	*0.0075*	*-0.0832*	*.4290*
CONSTANT	*-3.5117*	*.1887*	*0.0000*		
LAKE	*.7010*	*.3459*	*0.0427*	*0.0538*	*2.0157*
LT10	*-1.2853*	*.2753*	*0.0000*	*-0.1634*	*0.2766*
GT10	*-0.8795*	*.3177*	*0.0056*	*-0.0874*	*0.4150*
CONSTANT	*-3.5765*	*.1935*	*0.0000*		

Table 4.1.1 Odds ratios for environmental risk factors

Variable	Odds Ratio
1. Water supply	
* PHOUSE	1.0000
LAKE	2.0157
2. Number of household members	
* LT5	1.0000
LT10	0.2766
GT10	0.4150

** reference category*
All variables are significant at p=0.05 level of significance.

In Model 1b when all other factors are held constant, toilet facilities (flash toilet vs. others), age children use adult toilet (<3 years vs. >3 years) and main floor material (modern vs. earth) are seen not to be significant in predicting child death.

Water supply from the lake vs. piped supply is a significant predictor of death (twice the risk for those using lake water) when the other factors are held constant.

Overcrowding, measured by the number of members in a household is also a significant predictor of death (about 70% reduction in mortality risk for LT10 vs. LT5) and 60% reduction in mortality risk for GT10 vs. LT5).

Model 2 Logistic Regression results (for mothers with no education)

Variable	B	S.E.	Sig.	R	Exp(B)
F6	-1.6188	.4670	0.0005	-.2190	.1981
CONSTANT	-3.2278	.3555	0.0000		
LAKE	1.4424	0.5096	0.0046	0.1697	4.2309
F6	-1.6957	0.4719	0.0003	- 0.2286	0.1835
CONSTANT	-3.4501	0.3793	0.0000		
PUBTAP	1.3124	0.5741	0.0222	-0.1243	3.7152
LAKE	1.7783	0.5554	0.0014	0.1988	5.9197
F6	-1.5492	0.4812	0.0013	-0.2002	0.2124
CONSTANT	-3.8843	0.4639	0.0000		

Table 4.1.2 Odds ratios for environmental risk factors controlling for education (no education)

Variable	Odds Ratio
1. Source of drinking water	
* PHOUSE	1.0000
PUBTAP	3.7152
LAKE	5.9197
2. Main floor material	
* F1	1.0000
F6	0.2124

* Reference category
All variables are significant at p=0.05 level of significance

Source of drinking water remains a significant predictor of child death for mothers with no education (3.7 times the risk of death of children whose mothers use public tap, and 5.9 times the risk of death of children whose mothers use lake as the main water supply).

Main floor material is also a significant predictor of child death with about 80% reduction in child mortality risk for uneducated mothers having earth floor compared to those with modern floors. This is a rather interesting finding which we find hard to support. It could be because the sample is largely rural where modern floors are few so the majority of women live in earth floors thus giving a positive effect. It is also possible that the results may be masked by lack of specificity in the questionnaire items because there are different types of earth floors, e.g. smoothly plastered earth floors, those that are just hanging on and so on.

The third model is controlling for mothers with primary education only. Source of drinking water ceases to be a significant predictor of child death and instead we have toilet facility and number of household members.

Model 3 Logistic Regression results (for mothers with primary education)

Variable	*B*	*S.E.*	*Sig.*	*R*	*Exp(B)*
T3	*-0.8463*	*0.3483*	*0.0151*	*-0.0977*	*.4290*
CONSTANT	*-3.3863*	*0.2888*	*0.0000*		
T3	*-0.8403*	*0.3488*	*0.0160*	*-0.0964*	*.4316*
LT10	*-0.7933*	*.3304*	*0.0164*	*-0.0959*	*.4524*
CONSTANT	*-3.2014*	*.3172*	*0.0000*		
T3	*-0.7879*	*0.3503*	*0.0245*	*-0.0865*	*.4548*
LT10	*-1.1975*	*0.3630*	*0.0010*	*-0.1473*	*.3020*
GT10	*-0.9150*	*0.4416*	*0.0383*	*-0.0748*	*.4005*
CONSTANT	*-2.8338*	*0.3435*	*0.0000*		

Table 4.1.3 Odds ratios for environmental risk factors controlling for education (primary)

Variable	Odds Ratio
1. Toilet facility	
* T1	1.0000
T3	0.4548
2. No. of hsehold members	
* LT5	1.0000
LT10	0.3020
GT10	0.4005

* reference category
All variables are significant at p=0.05 level of significance

Pit latrine vs. flush toilet is seen to account for about 55% reduction in child mortality for mothers with elementary education.

Thus pit latrine has a protective effect on the risk of child mortality. Where members of the household are less than ten, the risk of child mortality is reduced by 70% and where they are greater than ten the reduction is slightly lower at 60% compared to those with less than five members.

There was no result output for mothers with higher education but this is not surprising because the effect of the environmental risk factors tend to have no significance with the increase in education level.

Model 4 Logistic Regression results (for mothers in urban area)

Variable	B	S.E.	Sig.	R	Exp(B)
T3	1.0243	.5132	.0460	.1012	2.7853
CONSTANT	-4.3340	.4432	.0000		

Table 4.1.4 Odds ratios for environmental risk factors controlling for residence (urban)

Variable	Odds Ratio
Toilet facility	
* flush toilet	1.0000
T3	2.7853

* reference category
All variables are significant at p=0.05 level of significance

Model 4 and 5 are controlling for urban vs. rural residence and here toilet facility remains significant predictor of child death for both cases. However, for mothers living in the urban area, pit latrine has 2.7 times the risk of death of children compared to flush toilet whereas pit latrine explains about 54% reduction in mortality risk of children of mothers living in rural area.

Model 5 Logistic Regression results (for mothers in rural area)

Variable	*B*	*S.E.*	*Sig.*	*R*	*Exp(B)*
T3	*-.7862*	*.3008*	*.0090*	*-.0946*	*.4556*
CONSTANT	*-3.9218*	*.2422*	*.0000*		
T3	*-.7670*	*.3012*	*.0109*	*-.0911*	*.4644*
LT10	*-.6256*	*.2899*	*.0309*	*3.0701*	*1.5349*
CONSTANT	*-3.6145*	*.2709*	*.0000*		

Table 4.1.5 Odds Ratios for environmental risk factors controlling for residence (rural)

Variable	Odds Ratio
1. Toilet facility	
* flush toilet	1.0000
T3	.4644
2. No. of hsehold members	
* LT5	1.0000
LT10	.5349

** reference category*
All variables are significant at p=0.05 level of significance

Where members of the household are more than five the risk of child mortality is reduced by 50% compared to where they are less than five for mothers living in the urban areas.

4.4 FURTHER DISCUSSION

The results presented above indicate that water supply and number of household members and toilet facilities are the consistent predictors of childhood death although the pattern that emerges is very interesting as we control for education and urban/rural residence. In the general model, lake vs. piped water (2 times the risk for those using lake) supply it is clear that mothers using lake water have their children at twice the risk of death due to contaminated water. It is however not clear whether the piped water is treated but it is nevertheless safer. The majority of lake users are to be found in the communities of Nyanza province where the childhood mortality has been found to be very high among lake users (q5 estimate of 215.3) in the demographic analysis.

Where members of the household are more than five, there tends to be a reduction in mortality for children of mothers living in the rural areas. This can be explained by the fact that when household members are more, then there is at least someone left at home to take care of the child even when the mother is busy outside the home. This could also be extended to mean that there are more productive members of the family who will assist in household duties like fetching water and firewood, farming, cooking and so forth and this is very important in enhancing family health. However, this argument may not hold unless the constitution of the household members is known so that if the majority of these members are much younger children, then it will have the adverse effect of increasing the risk of child death. When the number of household members exceeds ten, a drop in the protective effect of mortality risk is observed from 70% to 60% which suggests that there is a limit to how much the number of household members can be useful in explaining mortality reduction.

Water supply from the public taps (3.7 times the risk of child death) and lake (5.9 times the risk of child death) are significant for mothers with no education. This is reasonable as this is the population that is likely to be using either of these two sources of water. It is likely that public tap water is pumped directly from the lake and may not be treated as regularly as the water piped into the house but this is only a speculation. Mothers with no education may not take any precaution in treating the water before drinking and this is reflected in the fact that water supply ceases to be a significant predictor of child death for mothers with some primary education. Mothers with some primary education are also likely to have some sanitation facilities and make use of it more effectively for better hygiene. This then explains why pit latrine accounts for about 55% of child mortality reductions.

Number of household members appears as a significant factor for mothers with primary education accounting for up to 70% of reduction in risk of child mortality. This is an interesting observation which could be explained by the finding that mothers with primary education tend to have a higher fertility than those with no education at all (Ocholla-Ayayo, 1991). As seen in the previous model, when members exceed ten the reduction effect is lowered.

For urban residence, sanitation is the major risk variable with 2.7 times the risk for those without flash toilet. This could be explained by the fact that urban residents using pit latrines are likely to be living in much poorer areas in as far as environmental sanitation is concerned and are also likely to be of lower socio-economic group. Also the latrine may be communal whereas those in rural areas are basically used by family members only.

In the rural area, however, those using pit latrines are not necessarily of lower socio-economic class as that is the most common feature in the rural communities. It is also in the rural communities where the number of household members is an advantage to survival of children as there is someone to remain at home and take care of the child and also many hands to help in the tiring tasks of the household. Overcrowding is rarely an issue in rural areas as the members sleep in different houses according to the defined rules of the community.

In the urban area, overcrowding is likely to be a significant predictor factor of childhood mortality, although it did not feature in the model possibly due to insufficient data. Houses in the urban area have their own limitations such as small rooms and inadequate ventilation among others such that they are not adequate for large numbers of people and would thereby be a health hazard.

4.5 CONCLUSION

The above results and discussion suggest that the environmental risk factors that are associated with high childhood mortality risk are water supply and sanitation. Of notable significance is the water supply which appears in all the models and with lake users being at double the risk of experiencing mortality of a child than users of house-piped water. A safe and clean water supply is crucial to the health of family members and especially children as their body systems are sensitive to contaminated water. Good sanitation (this includes well-kept grass and well-drained compounds, a properly constructed and clean latrine/toilet, presence of a dumping pit far away from the main house, etc.) is paramount in a household.

Age at which children use adult toilet and main floor material are not significant predictors of childhood mortality in this analysis.

CHAPTER FIVE SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 SUMMARY

The general objective of this study was to identify and analyze the environmental risks of childhood death and to examine in some detail observed social factors which may influence these effects. The theoretical framework used in the study is that by van Norren and van Vianen (1986) which is a modification of the Mosley and Chen model.

In view of the conclusions and recommendations made by other researchers, the following hypotheses, stated in the null form were formulated:

(i) Physical living conditions and density of persons per house are powerful predictors of child death or survival.

(ii) Water supply and sanitation are direct causes of poor health and subsequently lead to child mortality.

Household size, source of water supply, type of housing, type of toilet facility and age at which children use adult toilet are the environmental risk factors identifiable in the data and used to explain childhood mortality in the country. The Kenya,DHS 1989 data is used in order to assess the usefulness of the data in undertaking such a study.

To be able to measure these parameters, two techniques are used in the study:

i) A demographic technique - Trussell's technique for the estimation of childhood mortality using defective data.

ii) A statistical technique - Logistic Regression model using the Statistical Package for Social Sciences (SPSS PC+) for analysis.

5.2 CONCLUSION

Some of the major findings in this report are that sanitation and water supply are the crucial environmental indicator of high under-five mortality rates. The logistic regression results also indicate that water supply is a high risk factor in determining mortality of children. Mothers with no education are affected a great deal more by environmental risk factors than those with primary education. As you move higher in the education level, the environmental risk variables cease to be a risk in childhood mortality. This could mean that mothers who have gone to school have an advantage of knowledge in how to manipulate the adverse environmental conditions so as to protect their family members for better health.

Although overcrowding was found to be significant in predicting child death, in the general model it was found to have a protective effect in risk of child mortality; but as the number of household members are more than ten, the effect of this advantage is reduced

About 85% of the Kenyan population lives in the rural areas, so it is not surprising that the general model exhibits such findings. In rural Kenya, overcrowding is rarely an issue of concern and is non-existent as the household compound known as the 'boma', consists of various housing structures in which the different members of the household sleep. This is in accordance with the traditional family set-up. The urban housing condition is, however, very different and this is where the term overcrowding becomes appropriate as the number of household members increases.

It is regrettable that the results from the Provinces could not be presented in this report due to poor quality data. Future studies should look at each province separately and identify the major risk factors associated with childhood mortality in each of them. This would assist planners in knowing how to tackle the problems of child mortality directly in each region.

Our conclusion must be that planners must look seriously into intervention programs which would accelerate providing of safe drinking water and access to sanitation services. The inducement of the community in the planning and implementation of such programs should be encouraged. To date, only 15% of the rural population (85%) has access to safe drinking water and only 19% of the same has access to sanitation services. This would go along way in helping/achieving one of the national population policy which is, "to reduce further mortality particularly the infant and child mortality, because such reductions would ultimately lead to lowering the fertility" (Population policy,1984).

These results are disappointing because they are only indicative of possible relationships and not strong enough to base strong recommendations for action upon. As mentioned several times in this report, the Kenya Demographic and Health Survey of 1989 is of poor quality because, we believe, it lacks clear hypothesis or theory underlying the construction of the survey instrument - the questionnaire. Were the questions and the categorizations for these variables appropriate for the setting in which the study took place? We found that Lake was a significant predictor of child death in Central Province. The difficulty in interpreting this finding lies in the lack of specificity of the questions asked. Does lake refer to any source of water that is not free flowing like a river? Is it water quality or quantity which is important and are these differences masked in our findings? Other key environmental factors such as type of housing, degree of crowding in the household, type of toilet facility were also either not sufficiently discriminatory or were not possible to measure with the items in the questionnaire.

5.4 RECOMMENDATIONS FOR FURTHER STUDY AND POLICY

Planners and researchers should take into account this lack of strong predictors in the design of further studies of risk factors.

A similar study be done using comprehensive data that has been collected with specific aim of analysing mortality risk of under-fives by environmental factors (household characteristics). This implies a detailed and well-designed questionnaire to facilitate the capturing of both qualitative and quantitative information. There's a need for proper organization, planning and co-ordination of data gathering.

Diarrhoea is a water-borne disease and its likely that those who suffer from diarrhoea use untreated water from unsafe water sources. A policy to discourage bathing at the water source should be implemented so as to reduce water contamination. Malaria too is a water-related disease and is responsible for the deaths of many children.

According to a Household Welfare Monitoring and Evaluation Survey (1991), 64% of households in South Nyanza have no toilet facilities. In areas where there's no facility or where buckets are used, pit latrines should be introduced and proper use of them be encouraged. If possible the Ventilation Improved Pit (VIP) latrines can be introduced for those who can afford them. The inducement of the community in the planning and implementation of such programs should be encouraged.

The Government of Kenya, through the District Focus for Rural Development, should accelerate efforts for provision of clean water supply in the rural area. This would play a major role in the decline of infant mortality. It would also relieve the mother of the drudgery of water collection from far distances so that she can have time for herself and for other development oriented activities within her community.

BIBLIOGRAPHY AND REFERENCES

Ahmed M.F. (1991):
Journal of biosocial science vol.23 no.3 1991 pp.327-36

AL-Hassan Couteh, Patricia H. David, and Evasius K. Bauni (1990):
Environmental Risk Factors of Childhood Mortality in Liberia: Evidence and Policy Implications. Determinants of Health and Mortality in Africa DHS Further Analysis Series Number 10 Apr. 1990.

Aly, Hassan Y. (1990):
Journal of Biosocial Science Vol.22 No.4 pp.447-51

Andrea, W.L. (1990):
An analysis of native mortality in Canada. *Research discussion paper* No.71, Pop. Research Lab. Dept. of Sociology; Univ. of Alberta.

Anker,R. (1980):
An empirical analysis of mortality differentials in Kenya at the macro and micro-level. *Population and Development Review* vol.6, No. 1.

Backett E.M.; A.M. Davies and A.Petros-Barvazian (1984):
The risk approach in health care. *Public Health papers* No. 76; World Health Organization.

Cornia, G.A.; R.Jolly and F.Stewart.(1988):
Adjustment with a human face, vol.II: country case studies. Oxford: Claredon press.

DHS World Conference (Aug.5-7,1991):
Washington, DC; Proceedings Vol.1 pp.137

Dissevelt A.G. (1978):
Integrated maternal and child health services; a study at a rural health centre in Kenya. Royal Tropical Institute, Medical Res. Centre, Nairobi, Dept. of Tropical Hygiene, Amsterdam.

Eduardo E. Arriaga; (1989):
Changing Trends in Mortality Decline during the Last Decades. US Bureau of the Census. Differential Mortality: Methodological Issues and Biosocial Factors by Lado Ruzicka ; Guillaume Wunsch; Peng Kane Clarendon Press, Oxford.

Enyolu, E (no date):
Death determinants in developing countries: The case of urban

health care in Nigeria. PhD. thesis, Division of Social Sciences, University of Toronto.

Eric A.Roth & Balan Kurup (1990):
Child mortality levels and survival patterns from Southern Sudan. *Journal of biosocial science* Vol. 22 No.3 July.

Ewbank, D.C.; Henin,R.A.; Kekovole, J. (1984):
An integration of demographic and epidemiological research on mortality in Kenya. Paper prepared as a case study for the WHO/UN joint project on the determinants of mortality in developing countries.

Farah, A.A. and S. Preston (1982):
Child mortality differentials in the Sudan. *Population and Development Review* 8:2, pp.365-383.

Fendall, N.R.E. (1965):
The incidence and epidemiology of disease in Kenya. Part 1: Some diseases of social significance. *The journal of Tropical Medicine and Hygiene*, Vol.68: 1-12. pp.77-84.

Gwatkin, D (9180):
Indications of change in developing country mortality Trends: The end of an era. *Population and development review*, Vol.6, No.4.

Hill K. & A.R.Pebley, (1989):
Child mortality in the developing world; *Population and Development Review*, 15 (4): 657-681.

IUSSP:
International population conference vol. 2 Manila 1981; vol.2

Jellife D.B. (1974):
Child health in the tropics. Edward Arnold (Publishers) Ltd.

Jose' Miguel Guzman; (1989):
Trends in Socioeconomic differentials in Infant Mortality in Selected Latin American countries." CELADE, Santiago,Chile.

Kenya Demographic and health survey (1989):
National Council for Population and Development (NCPD); Ministry of Home Affairs and National Heritage, Nairobi,Kenya.

Kibet,M.K.I. (1981):
Differential mortality in Kenya M.A. Thesis; University of Nairobi.

Kleinbaum D.G. and L.L.Kupper (1978):
Applied regression analysis and multivariate methods. University of North Carolina, Chapel Hill.

Kune, J.B. (1980):
Some factors influencing the mortality of under fives in rural areas of Kenya: a multivariate analysis. *Journal of Tropical Paediatrics* 26; pp.114-122

Maina-Ahlberg, B. 1979:
Beliefs and practices concerning treatment of measles and acute diarrhoea among the Akamba. Tropical and geographical medicine 31: pp. 139-148

Lado Ruzicka, ———:
Problems and Issues In The Study of Mortality Differentials. Demography Dept., Australian National University, Canberra, Australia.

Mosley W.H. PSRI,(1980):
Biological contamination of the environment by man. Biological and social aspects of mortality and the length of life. IUSSP,1980.

Mott, Frank L. (1979):
Infant mortality in Kenya: Evidence from the Kenya Fertility Survey.

Nyamwange, F. (1982):
Medical technology, socioeconomic status, demographic factors and mortality; the case of child mortality in Nairobi. M.A. thesis, University of Nairobi.

Obungu W.; Kizito,P.M; Bicego,G (1991):
Trends, age patterns and determinants of early childhood mortality in Kenya. NCPD, Kenya. Ocholla-Ayayo, A.B.C. (1991): The spirit of a nation, Shirikon publishers, Nairobi.

Ocholla-Ayayo A.B.C. and J.A.M. Ottieno (1992):
Housing conditions and child survival in Kenya. Fifth International Research Conference on Housing, Montreal: Workshop 6. Pop. Studies and Research. Inst.' University of Nairobi.

Onyemunwa, P. (1988):
IUSSP, *African population conference*, Dakar Vol.2

Ouma, F. Oduor; 1991:
Environmental Risk and Socio-economic Factors Influencing

Infant and Child Mortality in Siaya District: A Case Study of Jera sub-location. Msc. Thesis, University of Nairobi.

Pebley A.R. and S. Amin (1991):
The impact of public health interventions on sex differentials in childhood mortality in rural Punjab, India. *Working papers* No.24, Research Division.

Sessional paper no.4 (1984):
Population policy guidelines; National Council for Population and Development (NCPD).

Sicault G. (1963):
The needs of children. The United Nations Children's Fund, U.S.A.

Sixth Development Plan (1989-1993):
Government printer, Nairobi.

Sly, David F. (1991):
Journal of Biosocial Science Vol.23 No.3

UNEP (1991/92):
Environmental Data Report 3rd ed.

UNESCWA (1989):
Infant and childhood mortality in Western Asia.

Unicef (1989):
Situation analysis of women and children in Kenya. Section 1 & 4.

United Nations (1986):
Determinants of mortality change and differentials in developing countries: The five-country case study project.

United Nations (1985):
Socio-economic Differentials In Child Mortality In Developing Countries. Dept. of International Economic and Social Affairs, New York.

United Nations (1984):
International Conference on Population, Mortality and health policy Proceedings of the Expert Group on Mortality and Health Policy, Rome.

United Nations (1983):
Manual X, Indirect method for demographic estimations, New York.

van Ginneken,J.K. and A.S.Muller (1984):
Maternal and child health in rural Kenya: An epidemiological study; Groom Helm Ltd. London & Sydney.

Victora C.G.; J.P.VAUGHAN; B.R.Kirkwood; J.C.Martines; L.B.Barcelos (1986):
Risk factors for malnutrition in Brazilian children: the role of social and environmental variables. Bull. WHO, 64 (2): 299-309

Victora C.G.; P.G.Smith and J.P.Vaughan (1986):
Social and environmental influences on child mortality in Brazil: logistic regression analysis of data from census files. *Journal of Biosocial Science* vol.18 No. 1: 87-101

Walter P.A. (1986):
Role of the environmental factors in the decline of infant mortality: an analysis of the 1911 census of England and Wales. *Journal of Biosocial Science*:18,(1): 457-470

WHO (1988):
Urbanization and its implications for child health: Potential for action. Geneva.

World Bank, The 1991 World Development Report (1991):
New York: Oxford Univ. Press.

Yumkella F. (1988):
IUSSP, *African population conference*, Dakar Vol.2

Life Table for Rift Valley Province

Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.035024	0.964976	100000	3502.357	97548.35	6651640	66.5164
1	0.013556	0.986444	96497.64	1308.087	382458.7	6554091	67.9197
5	0.006649	0.993351	95189.56	632.9255	474365.5	6171633	64.83519
10	0.004655	0.995345	94556.63	440.2051	471682.6	5697267	60.25243
15	0.007687	0.992313	94116.43	723.4474	468773.5	5225585	55.52256
20	0.010949	0.989051	93392.98	1022.533	464408.6	4756811	50.93328
25	0.011741	0.988259	92370.45	1084.512	459140.9	4292403	46.46944
30	0.012809	0.987191	91285.93	1169.239	453506.6	3833262	41.99181
35	0.014517	0.985483	90116.69	1308.209	447312.9	3379755	37.50421
40	0.018766	0.981234	88808.48	1666.567	439876	2932442	33.01984
45	0.023884	0.976116	87141.92	2081.335	430506.3	2492566	28.60353
50	0.036014	0.963986	85060.58	3063.335	417644.6	2062060	24.24225
55	0.048291	0.951709	81997.25	3959.704	400087	1644415	20.05452
60	0.075657	0.924343	78037.54	5904.082	375427.5	1244328	15.94525
65	0.11995	0.88005	72133.46	8652.407	339036.3	868900.7	12.04574
70	0.189242	0.810758	63481.05	12013.26	287372.1	529864.5	8.346812
75+	1	0	51467.79	51467.79	242492.3	242492.3	4.711536

Western Province			
Age grp	FPOP(i)	CEB(i)	CD(i)
15-19	198	62	8
20-24	174	305	36
25-29	162	623	74
30-34	137	812	93
35-39	100	698	88
40-44	102	782	106
45-49	65	545	80

Age grp	P(i)	D(i)	K(i)	q(x)	l(x)		
15-19	0.313131	0.129032	0.966058	0.124653	0.875347		
20-24	1.752874	0.118033	0.991246	0.117	0.883		P(1)/P(2)
25-29	3.845679	0.11878	0.960908	0.114137	0.885863		0.178639
30-34	5.927007	0.114532	1.00105	0.114652	0.885348		
35-39	6.98	0.126074	1.065439	0.134325	0.865675		P(2)/P(3)
40-44	7.666667	0.13555	1.050735	0.142427	0.857573		0.455803
45-49	8.384615	0.146789	1.02871	0.151003	0.848997		

					lower	interpolated
Age grp	x	l(x)	low l(x)	upp l(x)	level	level
20-24	2	0.883	0.88265	0.89715	15	15.02417
25-29	3	0.885863	0.88444	0.90016	16	16.09053
30-34	5	0.885348	0.88533	0.90252	17	17.00103
average mortality level =			16.03858	lower mortality level =		

	l(x)	l(x)	actual
Age x	level 16	level 17	l(x)
0	1	1	1
1	0.9175	0.92764	0.917891
5	0.86818	0.88633	0.86888
10	0.84751	0.86868	0.848327
15	0.83592	0.85853	0.836792
20	0.82169	0.84564	0.822614
25	0.80298	0.82851	0.803965
30	0.78306	0.81027	0.78411
35	0.76166	0.79063	0.762778
40	0.738	0.76884	0.73919
45	0.71053	0.74319	0.71179
50	0.67915	0.71346	0.680474
55	0.63915	0.67473	0.640523
60	0.58955	0.62635	0.59097
65	0.52279	0.56009	0.524229
70	0.43442	0.47082	0.435824
75+	0.32398	0.35709	0.325257

Life Table for Western Province

Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.082109	0.917891	100000	8210.883	94252.38	5484265	54.84265
1	0.053395	0.946605	91789.12	4901.1	353923.5	5390013	58.7217
5	0.023655	0.976345	86888.02	2055.35	429301.7	5036090	57.96069
10	0.013597	0.986403	84832.67	1153.445	421279.7	4606788	54.30441
15	0.016944	0.983056	83679.22	1417.831	414851.5	4185508	50.01849
20	0.02267	0.97733	82261.39	1864.905	406644.7	3770657	45.8375
25	0.024697	0.975303	80396.49	1985.519	397018.6	3364012	41.84277
30	0.027206	0.972794	78410.97	2133.21	386721.8	2966993	37.83901
35	0.030924	0.969076	76277.76	2358.786	375491.8	2580271	33.82731
40	0.037067	0.962933	73918.97	2739.979	362744.9	2204780	29.82698
45	0.043997	0.956003	71178.99	3131.635	348065.9	1842035	25.87891
50	0.058711	0.941289	68047.36	3995.101	330249	1493969	21.95484
55	0.077363	0.922637	64052.26	4955.294	307873.1	1163720	18.16829
60	0.112934	0.887066	59096.96	6674.071	278799.6	855846.8	14.48208
65	0.168638	0.831362	52422.89	8840.472	240013.3	577047.1	11.00754
70	0.253696	0.746304	43582.42	11056.69	190270.4	337033.8	7.733252
75+	1	0	32525.73	32525.73	146763.5	146763.5	4.512227

Eastern Province

Age grp	FPOP(i)	CEB(i)	CD(i)	
15-19	258	65	7	
20-24	201	283	15	
25-29	234	771	50	
30-34	143	694	28	
35-39	171	1053	71	
40-44	131	945	132	
45-49	85	621	62	

Age grp	P(i)	D(i)	K(i)	q(x)	l(x)	
15-19	0.251938	0.107692	0.940931	0.101331	0.898669	
20-24	1.40796	0.053004	0.99886	0.052943	0.947057	P(1)/P(2)
25-29	3.294872	0.064851	0.975608	0.063269	0.936731	0.178938
30-34	4.853147	0.040346	1.017252	0.041042	0.958958	
35-39	6.157895	0.067426	1.082366	0.07298	0.92702	P(2)/P(3)
40-44	7.21374	0.139683	1.066403	0.148958	0.851042	0.427319
45-49	7.305882	0.099839	1.041986	0.104031	0.895969	

					lower	interpolated		
Age grp	x	l(x)	low l(x)	upp l(x)	level	level		
20-24	2	0.947056	0.93607	0.94758	19	19.95447		
25-29	3	0.936731	0.92898	0.94217	19	19.58764		
30-34	5	0.958958	0.9491	0.96339	21	21.68986		
average mortality level =			20.41066	lower mortality level =			20	

Life Table for Eastern Province							
Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.040992	0.959008	100000	4099.225	97130.54	6490720	64.9072
1	0.018336	0.981664	95900.78	1758.463	378855.3	6393590	66.6688
5	0.008691	0.991309	94142.31	818.2285	468666	6014735	63.88981
10	0.005756	0.994244	93324.08	537.1503	465277.5	5546069	59.42805
15	0.00885	0.99115	92786.93	821.1503	461881.8	5080791	54.75761
20	0.012441	0.987559	91965.78	1144.188	456968.4	4618909	50.22421
25	0.013381	0.986619	90821.6	1215.26	451069.8	4161941	45.82545
30	0.014625	0.985375	89606.34	1310.511	444755.4	3710871	41.41304
35	0.016611	0.983389	88295.82	1466.655	437812.5	3266116	36.9906
40	0.021119	0.978881	86829.17	1833.727	429561.5	2828303	32.57319
45	0.026489	0.973511	84995.44	2251.442	419348.6	2398742	28.222
50	0.038999	0.961001	82744	3226.959	405652.6	1979393	23.92189
55	0.0521	0.9479	79517.04	4142.818	387228.2	1573740	19.79123
60	0.080606	0.919394	75374.22	6075.62	361682.1	1186512	15.74162
65	0.126461	0.873539	69298.6	8763.58	324584.1	824830.1	11.90255
70	0.197944	0.802056	60535.02	11982.53	272718.8	500246	8.263745
75+	1	0	48552.49	48552.49	227527.2	227527.2	4.686212

Life Table for Central

Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.030856	0.969144	100000	3085.597	97840.08	6783636	67.83636
1	0.010168	0.989832	96914.4	985.4505	384996.9	6685796	68.98661
5	0.005213	0.994787	95928.95	500.106	478394.5	6300799	65.68193
10	0.003884	0.996116	95428.85	370.6579	476217.6	5822405	61.01305
15	-0.00296	1.002961	95058.19	-281.472	475994.6	5346187	56.2412
20	0.008097	0.991903	95339.66	771.9899	474768.3	4870192	51.08254
25	0.008717	0.991283	94567.67	824.3045	470777.6	4395424	46.47914
30	0.024742	0.975258	93743.37	2319.395	462918.3	3924647	41.86586
35	0.013005	0.986995	91423.97	1188.985	454147.4	3461728	37.86456
40	0.017073	0.982927	90234.99	1540.545	447323.6	3007581	33.33054
45	0.022128	0.977872	88694.44	1962.634	438565.6	2560257	28.86604
50	0.033951	0.966049	86731.81	2944.634	426297.5	2121692	24.46267
55	0.045811	0.954189	83787.17	3838.388	409339.9	1695394	20.23453
60	0.072351	0.927649	79948.79	5784.336	385283.1	1286054	16.08598
65	0.115459	0.884541	74164.45	8562.989	349414.8	900771.1	12.14559
70	0.183205	0.816795	65601.46	12018.49	297961.1	551356.4	8.404636
75+	1	0	53582.97	53582.97	253395.3	253395.3	4.729027

Coast Province				
Age grp	FPOP(i)	CEB(i)	CD(i)	
15-19	81	12	3	
20-24	88	122	17	
25-29	85	278	27	
30-34	91	439	106	
35-39	79	448	65	
40-44	36	272	39	
45-49	28	201	48	

Age grp	P(i)	D(i)	K(i)	q(x)	l(x)			
15-19	0.148148	0.25	1.153308	0.288327	0.711673			
20-24	1.386364	0.139344	1.049283	0.146212	0.853788		P(1)/P(2)	
25-29	3.270588	0.097122	0.974342	0.09463	0.90537		0.106861	
30-34	4.824176	0.241458	0.997303	0.240807	0.759193			
35-39	5.670886	0.145089	1.053857	0.152903	0.847097		P(2)/P(3)	
40-44	7.555556	0.143382	1.037843	0.148808	0.851192		0.423888	
45-49	7.178571	0.238806	1.018446	0.243211	0.756789			

					lower	interpolated		
Age grp	x	l(x)	low l(x)	upp l(x)	level	level		
20-24	2	0.853788	0.85246	0.86782	13	13.08649		
25-29	3	0.90537	0.89715	0.91089	16	16.59823		
30-34	5	0.759193	0.73789	0.7615	10	10.90231		
average mortality level =			13.52901	lower mortality level =			13	

Age x	l(x) level 13	l(x) level 14	actual l(x)
0	1	1	1
1	0.88497	0.89613	0.890874
5	0.80764	0.82886	0.818866
10	0.77729	0.80185	0.790282
15	0.76138	0.78736	0.775124
20	0.74346	0.77059	0.757812
25	0.72053	0.74896	0.73557
30	0.69624	0.72599	0.711978
35	0.67032	0.70143	0.686777
40	0.64202	0.67449	0.659197
45	0.61044	0.64404	0.628215
50	0.5757	0.61014	0.593919
55	0.53386	0.56857	0.552222
60	0.4831	0.51779	0.501451
65	0.41781	0.45153	0.435648
70	0.33545	0.36666	0.35196
75+	0.23793	0.26441	0.251938

Life Table for Coast Province

Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.109126	0.890874	100000	10912.63	92361.16	4897932	48.97932
1	0.080829	0.919171	89087.37	7200.818	336907.3	4805571	53.94223
5	0.034906	0.965094	81886.56	2858.311	402287	4468664	54.5714
10	0.019182	0.980818	79028.24	1515.881	391351.5	4066377	51.45473
15	0.022334	0.977666	77512.36	1731.164	383233.9	3675026	47.41212
20	0.029351	0.970649	75781.2	2224.229	373345.4	3291792	43.4381
25	0.032073	0.967927	73556.97	2359.171	361886.9	2918446	39.676
30	0.035395	0.964605	71197.8	2520.055	349688.9	2556559	35.90784
35	0.040159	0.959841	68677.74	2758.055	336493.6	2206870	32.13371
40	0.047	0.953	65919.69	3098.222	321852.9	1870377	28.37357
45	0.054592	0.945408	62821.47	3429.563	305533.4	1548524	24.6496
50	0.070207	0.929793	59391.9	4169.717	286535.2	1242991	20.92862
55	0.091939	0.908061	55222.19	5077.058	263418.3	956455.3	17.32013
60	0.131225	0.868775	50145.13	6580.314	234274.9	693037	13.82062
65	0.1921	0.8079	43564.82	8368.781	196902.1	458762.1	10.53057
70	0.284186	0.715814	35196.03	10002.22	150974.6	261860	7.440043
75+	1	0	25193.81	25193.81	110885.4	110885.4	4.401294

Life Table for National Level

Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.0726	0.9274	100000	7260.003	94918	5912343	59.12343
1	0.027788	0.972212	92740	2577.028	364002	5817425	62.72832
5	0.016716	0.983284	90162.97	1507.19	447046.9	5453423	60.48406
10	0.010005	0.989995	88655.78	886.984	441061.4	5006376	56.46982
15	0.013309	0.986691	87768.79	1168.096	435923.7	4565314	52.01523
20	0.018087	0.981913	86600.7	1566.315	429087.7	4129391	47.68311
25	0.019642	0.980358	85034.38	1670.203	420996.4	3700303	43.51537
30	0.021586	0.978414	83364.18	1799.535	412322.1	3279306	39.33712
35	0.024546	0.975454	81564.65	2002.089	402818	2866984	35.14984
40	0.030015	0.969985	79562.56	2388.089	391842.6	2464166	30.97143
45	0.036346	0.963654	77174.47	2804.979	378859.9	2072324	26.85245
50	0.050201	0.949799	74369.49	3733.427	362513.9	1693464	22.77095
55	0.066478	0.933522	70636.06	4695.76	341440.9	1330950	18.84236
60	0.09911	0.90089	65940.3	6535.322	313363.2	989509.2	15.00614
65	0.150693	0.849307	59404.98	8951.892	274645.2	676146	11.38197
70	0.230122	0.769878	50453.09	11610.36	223239.5	401500.8	7.957904
75+	1	0	38842.72	38842.72	178261.3	178261.3	4.58931

Nairobi			
Age grp	FPOP(i)	CEB(i)	CD(i)
15-19	113	35	3
20-24	139	176	14
25-29	104	244	16
30-34	75	280	24
35-39	47	222	24
40-44	32	162	13
45-49	14	71	6

Age grp	P(i)	D(i)	K(i)	q(x)	l(x)	
15-19	0.309735	0.085714	0.840332	0.072028	0.927972	
20-24	1.266187	0.079545	0.922925	0.073414	0.926586	P(1)/P(2)
25-29	2.346154	0.065574	0.920436	0.060356	0.939644	0.24462
30-34	3.733333	0.085714	0.973644	0.083455	0.916545	
35-39	4.723404	0.108108	1.043914	0.112856	0.887144	P(2)/P(3)
40-44	5.0625	0.080247	1.032826	0.082881	0.917119	0.539686
45-49	5.071429	0.084507	1.012924	0.085599	0.914401	

					lower	interpolated
Age grp	x	l(x)	low l(x)	upp l(x)	level	level
20-24	2	0.926586	0.92385	0.93607	18	18.22386
25-29	3	0.939644	0.92898	0.94218	19	19.80784
30-34	5	0.916545	0.90252	0.91884	18	18.85936
average mortality level =			18.96369	lower mortality level = 18		

Age x	l(x) level 18	l(x) level 19	actual l(x)
0	1	1	1
1	0.93737	0.94668	0.946342
5	0.90354	0.91987	0.919277
10	0.88879	0.90792	0.907225
15	0.88008	0.90061	0.899864
20	0.86855	0.89046	0.889664
25	0.85307	0.87664	0.875784
30	0.83656	0.86193	0.861009
35	0.81877	0.84605	0.845059
40	0.79897	0.82834	0.827273
45	0.77531	0.80681	0.805666
50	0.74747	0.78105	0.779831
55	0.71031	0.74575	0.744463
60	0.66353	0.70094	0.699582
65	0.59829	0.63722	0.635806
70	0.50874	0.54799	0.546565
75+	0.39234	0.42963	0.428276

Life Table for Nairobi Province							
Age x	nqx	npx	lx	ndx	nLx	Tx	e(x)
0	0.053658	0.946342	100000	5365.807	96243.93	6161623	61.61623
1	0.0286	0.9714	94634.19	2706.492	371229.2	6065379	64.09289
5	0.01311	0.98689	91927.7	1205.168	456625.6	5694150	61.94161
10	0.008114	0.991886	90722.53	736.0838	451772.5	5237524	57.73124
15	0.011335	0.988665	89986.45	1020.011	447382.2	4785752	53.18303
20	0.015602	0.984398	88966.44	1388.028	441362.1	4338370	48.76412
25	0.016871	0.983129	87578.41	1477.536	434198.2	3897008	44.49735
30	0.018524	0.981476	86100.87	1594.936	426517	3462809	40.21805
35	0.021047	0.978953	84505.94	1778.589	418083.2	3036292	35.92993
40	0.026119	0.973881	82727.35	2160.735	408234.9	2618209	31.64865
45	0.032067	0.967933	80566.61	2583.553	396374.2	2209974	27.4304
50	0.045353	0.954647	77983.06	3536.754	381073.4	1813600	23.25633
55	0.060287	0.939713	74446.31	4488.154	361011.1	1432527	19.24241
60	0.091162	0.908838	69958.15	6377.52	333847	1071515	15.31652
65	0.14036	0.85964	63580.63	8924.162	295592.8	737668.5	11.60209
70	0.216422	0.783578	54656.47	11828.88	243710.2	442075.7	8.088259
75+	1	0	42827.59	42827.59	198365.6	198365.6	4.631724

Central Province				
Age grp	FPOP(i)	CEB(i)	CD(i)	
15-19	240	60	5	
20-24	207	308	6	
25-29	185	578	26	
30-34	123	588	37	
35-39	125	799	51	
40-44	100	730	55	
45-49	80	559	40	

Age grp	P(i)	D(i)	K(i)	q(x)	l(x)			
15-19	0.25	0.083333	1.015162	0.084597	0.915403			
20-24	1.487923	0.019481	0.992927	0.019343	0.980657		P(1)/P(2)	
25-29	3.124324	0.044983	0.949925	0.04273	0.95727		0.168019	
30-34	4.780488	0.062925	0.986267	0.062061	0.937939			
35-39	6.392	0.06383	1.048888	0.06695	0.93305		P(2)/P(3)	
40-44	7.3	0.075342	1.035102	0.077987	0.922013		0.476238	
45-49	6.9875	0.071556	1.015559	0.07267	0.92733			

					lower	interpolated		
Age grp	x	l(x)	low l(x)	upp l(x)	level	level		
20-24	2	0.980657	0.97691	0.98439	23	23.50097		
25-29	3	0.95727	0.95465	0.96756	21	21.20293		
30-34	5	0.937939	0.93434	0.94911	20	20.24367		
average mortality level =			21.64919	lower mortality level =			21	

	l(x)	l(x)	actual	
Age x	level 21	level 22	l(x)	
0	1	1	1	
1	0.96397	0.97194	0.969144	
5	0.95011	0.96425	0.95929	
10	0.94346	0.96014	0.954288	
15	0.93889	0.9569	0.950582	
20	0.93148	0.96524	0.953397	
25	0.92104	0.95899	0.945677	
30	0.90996	0.95228	0.937434	
35	0.89801	0.92301	0.91424	
40	0.88464	0.91192	0.90235	
45	0.86767	0.89736	0.886944	
50	0.84657	0.87853	0.867318	
55	0.81565	0.84988	0.837872	
60	0.77576	0.81231	0.799488	
65	0.71643	0.75527	0.741644	
70	0.62969	0.67024	0.656015	
75+	0.50957	0.55002	0.53583	

APPENDIX

Trusell variant, when children are grouped by five year age group of mother.				
		North Model		
age grp	index (i)	a(i)	b(i)	c(i)
15-19	1	1.1119	-2.987	0.8507
20-24	2	1.239	-0.6865	-0.2745
25-29	3	1.1884	0.0421	-0.5156
30-34	4	1.2046	0.3037	-0.5656
35-39	5	1.2586	0.4236	-0.5898
40-44	6	1.224	0.4222	-0.5456
45-49	7	1.1772	0.3486	-0.4624

National level								
Age grp	FPOP(i)	CEB(i)	CD(i)	P(i)	D(i)	K(i)	qx	
15-19	1413	399	47	0.282378	0.117794	0.971775	0.11447	q1
20-24	1238	1966	166	1.588045	0.084435	0.990762	0.083655	q2
25-29	1268	4381	351	3.455047	0.080119	0.958901	0.076826	q3
30-34	949	4737	490	4.99157	0.103441	0.998635	0.1033	q5
35-39	860	5532	528	6.432558	0.095445	1.062832	0.101442	q10
40-44	654	4794	468	7.330275	0.097622	1.048299	0.102337	q15
45-49	431	3233	398	7.50116	0.123105	1.026653	0.126387	q20

Age grp	qx	l(x)	low l(x)	upp l(x)	lower level	interpolated level
20-24	2	0.916345	0.91089	0.92386	17	17.42056
25-29	3	0.923174	0.91499	0.92898	18	18.585
30-34	5	0.8967	0.88533	0.90252	17	17.66144
average mortality level=			17.889	lower mortality level = 17		

Age x	level 17	level 18	l(x)
0	1	1	1
1	0.92764	0.92737	0.9274
5	0.88633	0.90354	0.90163
10	0.86868	0.88879	0.886558
15	0.85853	0.88008	0.877688
20	0.84564	0.86855	0.866007
25	0.82851	0.85307	0.850344
30	0.81027	0.83656	0.833642
35	0.79063	0.81877	0.815646
40	0.76884	0.79897	0.795626
45	0.74319	0.77531	0.771745
50	0.71346	0.74747	0.743695
55	0.67473	0.71031	0.706361
60	0.62635	0.66353	0.659403
65	0.56009	0.59829	0.59405
70	0.47082	0.50874	0.504531
75+	0.35709	0.39234	0.388427