DIFFERENTIAL MORTALITY IN KENYA

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DECLARATION

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

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CONTENTS

LIST OF TABLES

APPENDICES (TABLES)

LIST OF FIGURES

ABSTRACT OF THE THESIS

This study is concerned with the investigation of the factors that influence infant/or early childhood mortality at the macro level. The factors investigated include the following district level variables: per-cent women with five or more standards of education; percent cases of malaria; hospital beds per 1000 persons; total fertility; population to health facility ratio; per capita high potential agricultural land as a proxy for rural income; kilometres of roads per 1000 square kilometres as a proxy for socio-economic development; percent urban; and population density.

The investigation is divided into six chapters. Chapter 1 gives the historical background of mortality in the developing countries, Africa and Kenya in particular. Chapter 11 discusses and presents all the data utilized in this research. Chapter 111 describes the models used in this study. Chapter IV is the analysis of infant/or child mortality differentials and their correlates in Kenya. Chapter V examines the relationship between infant/or child mortality and the educational levels of mothers. Chapter VI gives a summary of the findings, conclusions and recommendations for further studies. This is followed by appendices and references/bibliography.

A multivariate analysis was used to examine the 1979 mortality differentials in Kenya by district. Data for all the variables by districts were gathered and regression was performed on these data. It was found that a significant correlation exists between infant/or child mortality and education and malaria variables. The results for the other

variables were rather inconclusive.

Only four out of nine variables considered explained 52.5 percent of the variation present in the mortality index as compared to 59.4 percent explained by all the variables together. These variables were as follows: women's education, malaria, agriculture and population density.

The district data analysed in this study revealed that the variations in child mortality levels by district are partly a result of the existing educational differentials among the districts. Indeed, inter-regional differentials in mortality appeared to persist even after controlling for differences in women's educational levels. Thus women's education plays a major role as a major factor in mortality decline only.

All the hypothesized relationships were confirmed except for the 'hospital beds' variables whose positive relationship with child mortality as suggested by the regression results, was not anticipated.

CHAPTER I

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 General Background of Mortality in Developing Countries

Most developing countries of the world have experienced striking declines in mortality over the recent years. The most widely accepted view is that this decline was largely independent of economic factors and was mainly due to factors associated with government actions, such as disease control, improved medical technology and increased availability of medical facilities (Stolnitz, G.J., 1955, 1974). Several arguments have been raised which support this opinion. First, mortality rates have fallen in almost all parts of the world -- even in areas which have not experienced extensive economic development. Secondly, mortality has fallen very rapidly in a number of countries, so rapidly that economic development cannot explain these changes during these short periods of time.

However, there are many researchers who argue that economic factors have made an important contribution towards decreasing mortality rates during the post-war period. Both Rodgers and Preston, in their studies of the relation between economic development and mortality argue convincingly that the non-linearity of the relation between life expectancy and income (an index of socio-economic change) at the micro-level justifies the inclusion of inequality of income as a variable in the cross-section analysis at the macro-level. In particular, Preston using national income as an index of socio-economic change, studied the relationship between national infant mortality rates and the levels of income and found correlation coefficients to be consistently high, of the order of -0.8 (Preston, H.S., 1975). Other researchers in support of economic development point out that even in

Sri Lanka, where mortality rates fell dramatically following an anti-malaria campaign, they fell dramatically in previously non-malaria areas as well (Frederiksen, H. 1971). They also point out that gastro-intestinal infections which are among the major causes of mortality in the less developing countries, are not very responsive to inexpensive forms of medical treatment (Schultz, T.P., 1976).

There are, however, strong indications that a large part of the decline in mortality in this century, in both high and low-income countries, is due to control of infectious and parasitic diseases and respiratory tuberculosis. The persisting high levels of diarrheal disease and resulting mortality among children in the less developing countries are not readily linked to the provision of modern medical services, but to the provision of better nutrition and living conditions that depend for the most part, on increases in levels of private income and their nearly equal distribution among persons (Hauser, 1979, p. 244). The further decline in childhood mortality increasingly depends on improved levels of living and, as suggested in this study, on increased maternal education.

1.2 Mortality in Africa

The study of mortality has long been a neglected area in almost all the countries of Africa south of the Sahara. This has been the case because of the fact that mortality data have since been incomplete in many countries. Where reports are available at all, they are limited to the available census data or sample surveys taken at different points in time.

The 1979 Population Reference Bureau estimates for all African countries show clearly that infant mortality rates on the continent are higher than the world mean. According to these estimates overall infant mortality for the whole world is about 95 infant deaths per 1000 births while all but 5 of the 52 African nations for which data are available have estimated infant mortality rates above this level. (Table 1.1).

TABLE 1.1 ESTIMATED INFANT MORTALITY RATES FOR AFRICAN COUNTRIES WITH POPULATIONS OF OVER 10,000,000

Country	I.M.R.	Country	I.M.R.
Ethiopia	162	Uganda	136
Zaire	160	Morocco	133
Nigeria	157	Tanzania	125
Algeria	142	Ghana	115
Sudan	141	Egypt	108
Mozambique	140	South Africa	92

Source: 1979 World Population Data Sheet, Pop. Ref. Bureau Inc, Washington, D.C.

Although the reliability of these estimates may be questionable, the data are nonetheless useful for suggesting the general orders of magnitude and range of infant mortality in Africa. Table 1.2 which summarizes all these estimates, suggests that average infant mortality in Africa is above 140 infant deaths per 1000 live births.

TABLE 1.2 DISTRIBUTION OF ALL AFRICAN COUNTRIES BY LEVEL OF INFANT MORTALITY (INFANT DEATHS PER 1000 BIRTHS)

Total	52
Under 100	6
100-119	6
120-139	9
140-159	12
160-179	11
180 and Over	8

Source: 1979 World Population Data Sheet, Population Reference Bureau, Inc., Washington D.C.

There is a growing literature on mortality differentials in Africa which suggest several relationships between mortality and many of its determinants but does not answer several questions. There is, for example, a general agreement that increasing educational attainment is associated with declines in mortality among infants and young children (Caldwell, 1979; Brass, 1979; Anker and Knowles, 1977; Mott, 1979). Caldwell (1979) attributes the inverse relationship between educational attainment and infant/or child mortality to many causes. These include the likelihood that more education is linked with breaks with traditional family raising habits; less fatalism about illness; more effective child care and medical alternatives; better utilization of available foods, from a nutritional perspective and more personal and intensive attention by the mother with more of the family resources spent on the child.

Polygamy has also been found in some instances, to be associated with an average level of infant mortality (Caldwell, 1979) as are first and high parity births. Infant mortality risk among high parity births is increased by having those births spaced closely together. In this context, even a relatively modest parity birth (for example a third child) runs a high risk of dying if it occurs soon after the second birth (Pringle, et. al., 1969).

Another rather general finding in Africa is the sex differential in infant and child mortality. Within the African situation significantly higher infant and child death probabilities have been found among male births as compared with female births (Anker and Knowles, 1977; Page, 1979; United Nations, 1979; Mott. 1979). No clear explanation has been provided for this sex differential in early childhood mortality.

There is also unclear evidence regarding the status of the relationship between mortality and urban residence. Although there is considerable data indicating an inverse relationship between infant/or child mortality and urban residence (United Nations, 1973; Page, 1971; Gaisie, 1979; Mott 1979), yet it has become more likely that this inverse relationship does not reflect urban or rural residence as such but rather other factors related with urban or rural living. In fact, there are a number of studies which suggest no significant inverse association between urban residence and infant mortality within a multivariate context (Caldwell, 1979; Anker and Knowles, 1977). Other factors such as ecological, social, economic, occupational, educational attainment, health conditions, ethnic group membership, geographic residence, altitude, marital status and family size may be the actual explanatory factors in explaining urban-rural mortality differentials.

Increasing proportions of infant deaths, in particular, are known to be associated with factors related to the environment in which the infant lives (Conde and Boute, 1971; Clairin, 1968; United Nations, 1973: Cantrelle, 1971). Thus external health and nutritional factors determine the survival chances of infants and young children.

1.3 Mortality in Kenya

In Kenya, changes in mortality over time appear to have paralleled the experience of other developing countries. In the late nineteenth century mortality rates were very high. Famines were common; tribal warfare was always a threat; medical care was poor; and malnutrition was abundant. A rough estimate of life expectancy at birth at this time could hardly have exceeded 30 years by much, and was in all probability lower (Anker and Knowles, 1977, p. 2). The situation has changed following the country's colonization by the British and the subsequent attainment of independence.

The earliest data on mortality in Kenya were estimated crudely from data that were often collected for other than demographic purposes. Slave raids and tribal raids of the nineteenth century claimed many lives. Malaria, sleeping sickness, plague and malnutrition still plagued the African population (Kuczynski, 1949, pp. 190-201).

Earlier records, summarized by Kuczynski, reveal infant mortality ranging from 118 to 413 per 1000 in different surveys taken by different medical officers in Kenya during the 1920's and 1930's. The 1922 survey taken in the Kavirondo District indicated an infant mortality rate of 413 infant deaths per 1000 births. Infant mortality rates of 118, 277 and 237 were suggested by similar surveys taken in 1925, 1926 and 1927, respectively (Kuczynski, 1949). The lower rates were attributed to the varying incidence of malaria during the survey years. Another survey among the Masai revealed that of 2,817 children born to 907 women, 1,260 had died -- a child mortality rate of about 447 deaths per 1000 live births.

There is very clear and consistent evidence that Kenya has experienced a progressive decline in mortality since the first census in 1948. The 1948 census estimate of child mortality rate was put at 184 deaths per 1000 children (Herz, 1974, p. 271). Available evidence suggests that mortality has continued to decline sharply since 1962 in Kenya (Kenya Central Bureau of Statistics, 1979; Henin and Mott, 1979). Crude death rate fell between 18 and 23 per 1000 in the 1962 census, to 17 per 1000 in the 1969 census and to 14 per 1000 in the National Demographic Survey. Life expectancy at birth for both sexes rose from about 40 to 45 years in 1962 to 46.9 years for males and 51.2 years for females in 1969. Blacker (1979), estimated a further rise in life expectancy at birth to 51.2 years for males and 55.8 years for females from the National Demographic Survey in 1977.

It is also evident from studies based on the Kenya Fertility Survey that infant mortality, in particular, has been experiencing dramatic declines over the recent years. The best estimate to date of infant mortality trends comes from the analysis of birth histories in the 1978 Kenya Fertility Survey carried out by Mott (1979). This revealed for women age 15-34 an infant mortality rate of 159 per 1000 prior to 1958; 109 in the period 1958-1967, and 92 in the period 1968-1976. These figures are consistent with estimates derived from the census. These studies have demonstrated that the most dramatic differentials in infant and child mortality are regional. According to these studies, Central Province which is the most prosperous highland area has the lowest mortality; lower levels of mortality are also seen in the adjacent Rift Valley and Eastern Provinces. The highest levels of mortality are seen in Nyanza Province and Western Province adjacent to Lake Victoria, and Coast Province to the east. It has been suggested that this variation reflects the more tropical climate in the latter areas which is associated with a different pattern of illness causation than is found in the former areas (Mott, 1979). There are many ecological and cultural differences between these provinces that may account for these mortality differentials.

A multivariate analysis by Anker and Knowles (1977) examined 1969 mortality differentials by district and considered as district level variables the following: percent literate, percent urban; malaria endemicity; hospital beds per 1000 persons; total fertility rate; and a farmland proxy for rural income per capita. They found a significant correlation with the malaria variable. The results for the other variables were inconclusive.

Some evidence for the impact of malaria on mortality comes from a study by Payne, et. al., (1976) carried out in Nyanza Province during the period 1972-1975. In this investigation, the impact of a new insecticide was tested in terms of its impact on malaria incidence and on infant mortality. There was a treated population of 17,000 and a control population of 3,800 persons. The malaria incidence rate decreased by 96 percent in the treated area over the 3 year period. The estimated infant mortality in the untreated area was 157 per 1000 while in the treated area it was 93 per 1000. This difference was attributed to a reduction in the incidence of malaria produced by the insecticide programme.

Maternal educational levels as well as rural and urban residence have also been shown to be important factors associated with differentials in infant mortality (Anker and Knowles, 1977; Muganzi, Z.S., 1978, p. 228).

Epidemiological studies of mortality by cause of death have been limited by the availability of data, and have been based mostly on hospital records. Grounds (1964a) analyzed child mortality under 6 years of age in government hospitals in Kenya using the 1962 death registers. He found that respiratory tract infections was the leading cause of death followed by gastroenteritis, malnutrition, malaria, tetanus, whooping cough, meningitis, prematurity, burns, and measles in that order.

One problem with cause of death analysis is that typically only the primary cause is identified and important associated causes may be overlooked. Grounds (1964b) in a further study of childhood mortality designed a prospective study in 15 hospitals in 1963 to measure the frequency with which malnutrition was a contributory cause of death. He found among 243 deaths over a one month period that 47 percent of children who died were malnourished at the time of admission to hospital. Malnutrition was associated with 63 percent of deaths due to gastroenteritis and 26 percent of deaths due to respiratory tract infections.

Kenya has a Vital Registration System. Deaths are reported annually by the Office of the Registrar General by age, sex, race, location and cause. Although death registration is incomplete it is possible to make some inferences regarding causes of death by age, sex and region from these registration data. The registered deaths by cause for the year 1973 showed that overall 46,992 deaths were registered of which 14,750 (31.4 percent) were infants.

Comprehensive field-based epidemiological studies of mortality have been extremely limited in Kenya. The best series of investigations come from the longitudinal studies in a rural population of 24,000 inhabitants of Machakos District living in nearly 4,000 households which have been conducted since 1974 by the Medical Research Centre of Nairobi (a department of the Royal Tropical Institute of the Netherlands). These investigations have provided not only a general demographic, but have included detailed investigations of specific causes of death and also looked at beliefs and practices related to morbidity and mortality in the rural areas. An introductory paper provides background information (Muller, et. al., 1977).

A number of studies based on these longitudinal data on demography and some aspects of health and disease of mothers and children collected in the Machakos project area, have been done. Three cross-sectional surveys have been carried out to study the relationships between mortality determinants and the patterns of morbidity and mortality, as observed in the child population (Kune, Slooff and Schulpen, 1979; Slooff and Schulpen, 1978 and Kune, 1979).

1.4 Objectives of the Study

The main objective of this study is to analyse mortality differentials in Kenya based on the 1979 census data and the available ecological, demographic, health, disease and economic data. More specifically, the study attempts to investigate whether or not differences in mortality among the Kenyan districts are related to the mortality determinants in a consistent and logical manner. To do this it is necessary to test the significance of the relationship between mortality on one hand and socio-economic, demographic, ecological, medical and disease conditions on the other.

Each of the following hypotheses has, therefore, been tested:

i) The percentage of the women population which has achieved five or more school years is expected to be negatively related to mortality;

ii) The amount of high-potential agricultural land per capita is negatively related to mortality;

iii) The number of hospital beds per 1000 persons is expected to be negatively related to mortality;

iv) Parity (order of births) is expected to be positively related to mortality;

v) Urbanization is expected to have an inverse association with mortality;

vi) The number of persons per health facility is expected to be positively related to mortality;

vii) The number of kilometres of roads is expected to be negatively related to mortality;

viii) The endemicity of malaria is expected to be positively related to mortality;

ix) Population density is expected to be positively related to mortality.

A multivariate analysis was carried out to find out which of the mortality determinants are highly significant. A number of studies have suggested that the major socio-economic factor which explains the highest degree of association with mortality is education of women. An attempt has been made in the present study to analyse differentials in mortality by educational levels of women.

The present analysis also aims to determine the extent to which the different factors are of greater or lesser importance as mortality predictors in 1979 as compared with the 1969 empirical results obtained by Anker and Knowles (1977).

1.5 Significance of the Study

It is expected that the results of the present analysis will be beneficial to the government for purposes of economic and social planning. Uniformities and differences of mortality within a country reveal the distribution of other related factors. The study has attempted to come up with a better understanding of the relationship between mortality and its variant influences. Such an understanding would be useful in the making of concrete public policies geared towards the improvement of socio-economic and health status of the districts. Mortality, one of the principal variables of demographic analysis, is a key measure of health and economic status.

In particular, infant mortality rates are one of the most common indices of socio-economic development. It is also a common index of health, nutrition and demographic status. In fact socio-economic development means rising life expectancy, declining infant and maternal mortality, and improved nutritional status. So knowing the variations in mortality levels among the various districts means having a picture of their levels of socio-economic development. Such a picture would be useful in making social and economic policies.

This research study will also be beneficial in the academic sphere for students and other scholars interested in mortality studies. An indepth analytical study investigating fully the causes and factors responsible for mortality differentials is still lacking. It is, therefore, hoped that this study will open up new areas that deserve more investigation.

1.6 Work Done in This Thesis

The major content of this thesis has been divided into six major chapters. Following the introductory chapter (Chapter I) is Chapter II which is mainly a description of all the variables used in this analysis. This includes the data sources, availability, limitations and anomalies of the data utilized. In this chapter the quality of the census data used is examined. Chapter III details the models used in the present study and the limitations of such models. In this chapter, an overview of the analytical models including Brass technique for mortality estimates, and the statistical techniques employed in the empirical analysis of mortality differentials is given.

Chapter IV deals with the application of the methodology developed in chapter III to the Kenyan census data and other available data, with a view to finding out their empirical relationships. This chapter begins by examining the variability in the levels of infant and child mortality by district with a view to identifying the geographical clustering of high and low mortality regions. The multiple regression results are presented in this chapter.

Chapter V examines the relationship between mortality and educational levels of mothers. This chapter discuses the impact that education has on differential mortality by examining the mortality situation among children born to women with different levels of education. The role played by education in bringing about the existing mortality differentials is the main investigation of this chapter.

The final chapter (Chapter VI) deals with the summary of the findings, conclusion and recommendations for further studies. This is followed by appendices and bibliography.

The scope of this study is limited in that it did not deal with all the possible factors that influence infant and child mortality. This was due to the lack of measures for the other possible independent variables that have a direct impact on infant and child mortality such as nutrition, infectious diseases and other environmental factors. Thus all the possible factors that may have caused the present mortality levels were not investigated.

CHAPTER II

DATA AVAILABILITY AND LIMITATIONS

CHAPTER II

DATA AVAILABILITY AND LIMITATIONS

2.1 Introduction (Background Information on the Selected Variables)

In this chapter a detailed description is given on the sources and measures of data for all the selected variables. The sources, quality, limitations and anomalies of the data are discussed in the relevant sections of the chapter. In this section an outline on the background of the selected variables is given.

One principal measure of infant and child mortality levels for all the districts has been used in this study: the probability of dying before age 2-q(2). In certain instances, additional measures have been used for differential mortality studies. For example, crude death rate was used for the study of mortality differentials and their correlates in Africa (WHO, 1979, p. 20-34) and life expectancy at birth (e_o) was used by Anker and Knowles in their empirical study of mortality differentials in Kenya (Anker and Knowles, 1977).

However, crude death rate is obviously a very unsuitable parameter to be used for comparisons in place and time as it is heavily affected by the age and sex distribution of the population which constitutes the denominator. Life expectancy at birth (e_o) could not be used because it is a measure of mortality risk at various periods of life while this analysis is a study of differential mortality among young children. Thus q(2) has been chosen as a measure of mortality among infants and young children.

This principal measure of infant/child mortality is described fully in chapter III. This chapter only describes the data necessary for the estimation of this parameter.

Nine independent variables have been chosen for this study, namely: malaria; women's education; urbanization; population density; parity (as measured by total fertility rate); hospital beds; health facilities, agriculture and kilometres of roads.

Malaria is a systemic disease, acute, sometimes severe and often chronic. It is today man's dangerous parasitic disease particularly in tropical and sub-tropical regions where it has been directly or indirectly responsible for untold human suffering and economic deprivation. This disease is thought to have reached its maximum point of dissemination between the years 1900 and 1930 when it affected about 350 million people yearly. A case fatality rate of 1 to 2 percent was experienced at this time (Robert, J.M.D., 1974).

There is considerable evidence that malaria has been in existence in the humid low-lying areas of the coastal plains and around the shores of Lakes Victoria and Tanganyika in East Africa from time immemorial. It then spread along the Nile and other great rivers of East Africa following the main caravan routes. Migration of people in East and Central Africa also resulted in the spread of malaria from one region to another both in the long term and short term scale (Prothero, R.M., 1961, p. 24, 405).

Many highland areas of Kenya above 1600m. were virtually malaria-free as ascertained from early travellers. However, from 1902 onwards, epidemics of malaria were reported in Nairobi (Symes, 1940, p. 291). Around this period, the Nandi and Uasin Gishu Plateau (1900 m.) was reported free of malaria. Matson (1954) has written about the history of malaria in Nandi District. He observes that Nandi District, formerly, had a high reputation for a most salubrious climate. Then malaria, thought to have been imported by soldiers returning from Tanganyika after World War I, gradually gained a foothold in the district. Sporadic outbreaks of malaria were reported in the district by 1920 and by 1930 marked outbreaks were a feature every 3 to 4 years with a high case fatality rate (Matson, 1954, p. 431). Other areas of Kenya like Masailand, Central and Rift Valley Provinces are known to have experienced a similar disease pattern.

Obviously, the main causes of the spread of malaria to hitherto malaria-free areas has been the increasing rate of population movement resulting from the construction of roads, increased trade, commerce and urbanization.

Bonte (1971, p. 87) has noted that malaria ranked as the third cause of death among in-patients in government hospitals in 1968, accounting for 5 percent of all deaths.

A number of studies have shown that malaria has serious implications for mothers and their children during periods of pregnancy. An example of such studies is that of Kortman (1972) in which he studied the effect of pregnancy on malaria immunity and the implications of mother and child in Muheza, Tanzania. The implications of malaria control measures and their interruption on demographic factors were studied in the Pare Taveta in the early sixties by Pringle (1969).

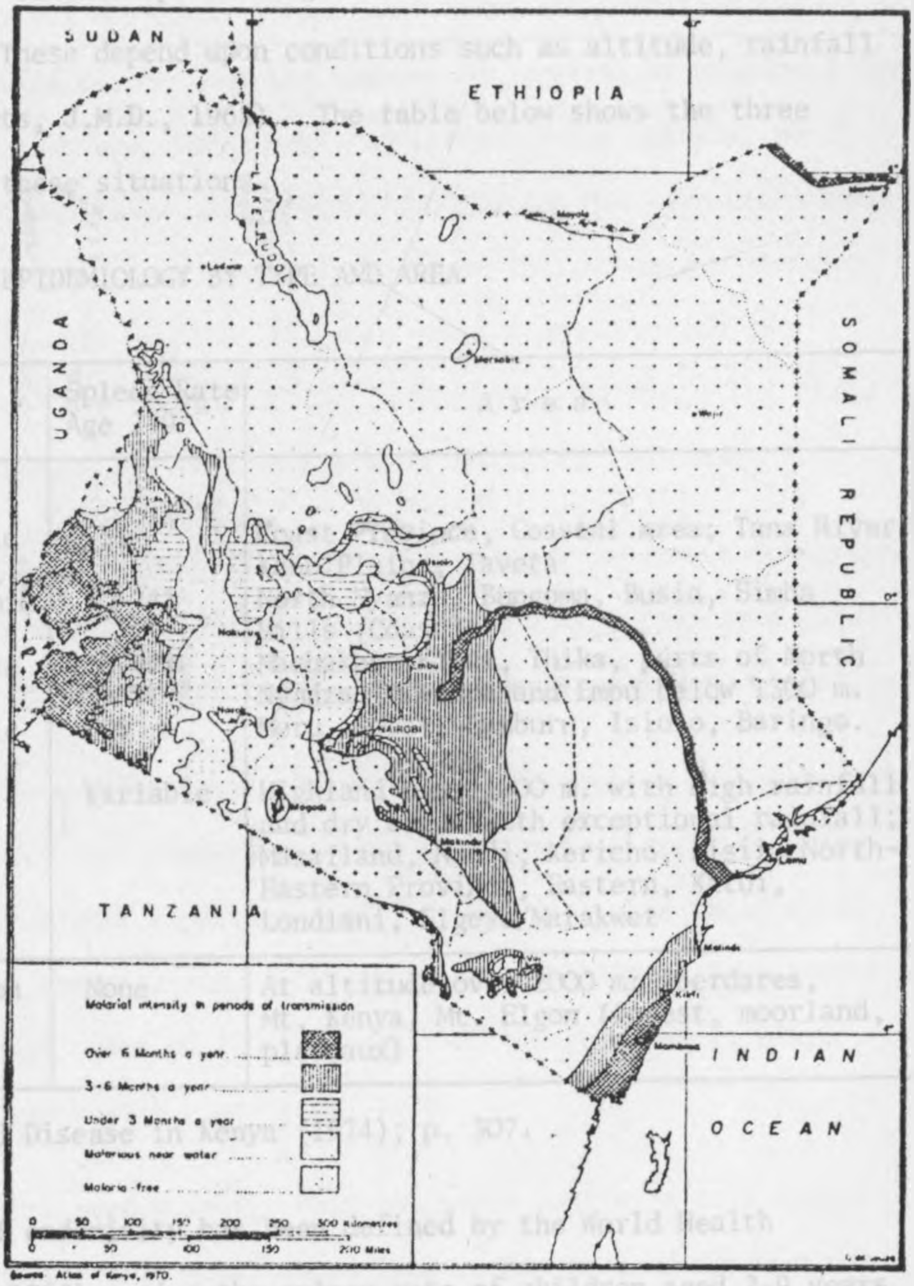

Fig. 2.1 Malarial Intensity in Periods of Transmission.

Fig. 2.1 shows the distribution of malaria in Kenya. Almost all the areas over 2,000 m. are virtually malaria-free, as is the whole of the northern half of the country (mostly desert) except those areas close to permanent waters. However, there have been epidemics in areas at an altitude of up to 3,000 m. (Garnham, 1948 and Fendall, 1965).

Three clearly defined epidemiological situations have been clearly defined in Kenya. These depend upon conditions such as altitude, rainfall and humidity (Roberts, J.M.D., 1968). The table below shows the three zones representing these situations.

TABLE 2.1 MALARIA EPIDEMIOLOGY BY TYPE AND AREA

Classification/ Degree	Spleen Rate Age 2-9	A r e a
(1) Endemic		
a) holoendemic	>75%	Coast Province, Coastal area; Tana River, Kano Plains, Taveta
b) hyperendemic	50-74%	North Nyanza, Bungoma, Busia, Simba Hills (Coast)
c) mesoendemic	10-49%	Machakos, Kitui, Thika, parts of North Nyanza, Muranga and Embu below 1300 m.
d) hypoendemic	<10%	Meru, Pokot, Samburu, Isiolo, Baringo.
(2) Epidemic	Variable	Highland over 1000 m. with high rainfall and dry areas with exceptional rainfall; Masailand, Nandi, Kericho, Kisii, North-Eastern Province, Eastern, Kitui, Londiani, Elgeyo/Marakwet
(3) No Transmission	None	At altitude over 2000 m: Aberdares, Mt. Kenya, Mt. Elgon (forest, moorland, plateaux)

Source: Health and Disease in Kenya (1974); p. 307.

The degree of endemicity has been defined by the World Health Organization (WHO, 1968), using the spleen rate of children aged 2-9 years as a parameter. The sources and measures of data on malaria endemicity for the present analysis are discussed in Section 2.4.

Women's education has generally been considered as an important factor which affects mortality of infants and young children. A detailed background on this subject has been presented in Chapter V of this thesis.

Maternal education obviously affects post-neonatal mortality for infants and young children, because the chances of survival at childhood are influenced by the social and educational conditions of the mothers, which determine their diet and child care. Women's education has been considered rather than man's because it is generally believed that women are the ones responsible for child care and that the more years a woman spends in school, the more aware she becomes of the factors that determine her child's health. The data sources for this variable is discussed in Section 2.2.

This study also considers urbanization as another important demographic aspect which affects the levels of infant and child mortality. As a major socio-economic factor, it is expected to be negatively related to mortality.

In fact all the available mortality statistics compiled by international institutions and individual researchers have shown quite clearly that the urban dwellers enjoy higher expectation of life at birth than their rural counterparts. While the majority of cities in tropical Africa have infant mortality rates of the order of 100/1000, that of the rural areas often exceed 200/1000 (World Health Statistics, 1976).

In Kenya, it has been observed that the urban dweller's life expectancy at birth is, on the average, 7 years longer than that of their rural counterparts (Muganzi, 1977, p. 228). Findings of mortality studies undertaken in many parts of tropical Africa portray a picture of higher death rates in the rural areas than in the urban areas with the large cities exhibiting the lowest mortality levels. Such findings include those that have been done in Ghana, Sierra Leone, Sudan and Ethiopia (Gaisie, 1976, p. 114-134; Tesfay, 1977, 233 ff; Rizgalla, 1977, p. 235, 237; and Gebretu, 1977, p. 142).

The process of in-migration to urban areas has an impact both on the rural and urban life. In the rural areas this process depletes the active labour force which retards development and land utilization. Mothers and dependent children are over-burdened sometimes with no material support from the men who have gone to urban centres to look for employment opportunities. On the other hand, this process creates heavy population pressures common in many urban areas. This has a greater impact on urban infrastructure. Problems such as concerns housing, water supply, waste disposal and transportation are made more difficult. Undoubtedly, these problems have a serious impact on the urban environment.

Other social and medical implications of urbanization include unemployment, marital problems for migrant workers, venereal diseases, crime, alcoholism, traffic congestion or accidents, inefficient infrastructural equipment and nutritional problems.

Because of these serious social implications of urbanization, the Kenya Government has actively discouraged migration to the urban areas. In fact, the principal objective of the Kenya Government, as formulated in the current Development Plan (1979-1983), is the alleviation of poverty in the rural areas. One of the specific objectives behind this decision to improve the rural areas is to reduce the rate of migration towards the cities. The large numbers of the unemployed and under-employed persons, many of whom are school leavers pose serious social and political problems.

The data on urbanization by District is presented in Section 2.2.

Another factor which is thought to influence infant and child mortality is population density. Greater population pressure may lead to a wider spread of infectious diseases when they occur. This may also create nutritional problems and many other social and medical problems such as housing, inadequate water supply and/or waste disposal systems and transportation. The density of population by Districts is discussed in Section 2.2.

Parity has been observed to be related to birth weight and infant/or child mortality rates in developed countries. Whereas the biological factors contribute to the first-order correlation between mortality and parity, economic factors may also contribute to this type of correlation. Obviously larger families put added strain on the family resources and hence reduce the amount of income that can be used for the care-taking of infants and young children. At the district level there is information on fertility rates which can be used to proxy for higher parity births. This is the subject of section 2.2.

Health services (hospital beds and health facilities) were selected as indices of health status of the population at the district level. Their utilization may have a crucial effect on infant and child mortality. In

Kenya, health services are provided by the Central Government, the local authorities, missions and private agencies such as companies and doctors in private practice. All these agencies serve on the lines of preventive, promotive and social medicine. The largest provider of medical services throughout the country is the Ministry of Health and is charged with the responsibility of looking after the health of the nation. It coordinates with the international health agencies in the implementation of priority programmes to control and prevent diseases.

A number of projects to combat diseases are now being undertaken with the co-operation of WHO/UNICEF/FAO/UNDP. These include projects to combat sleeping sickness, malnutrition, tuberculosis, small pox, malaria and measures to improve the environmental sanitation of the rural parts of the country.

In 1978 there were a total of 14,206 hospital beds in the 79 Government hospitals scattered all over the country.1/ The Kenyatta National Hospital in the capital city of Nairobi is the biggest and is a referral general hospital. The rest of the seven provinces of Kenya each has one provincial referral general hospital.

In 1978 there were 57 district hospitals. This is an improvement over that of 1967 which was estimated at 49 (Atlas of Kenya, 1970, p. 30).

At the rural level, health services are provided at the Health Centres

1/ Statistics for the mission, company and private hospitals for the period under study were still under the process of being collected by the Ministry of Health by the time of this study. Therefore, it was not possible to include them in the present analysis.

(HC), Health Sub-Centres (HSC), dispensaries and static or mobile clinics. The Health Centres are mobile so their staff can provide out-patient treatment to surrounding areas.

In 1978 there were 193 Health Centres which provided an outpatient service and at least 4 maternity beds in each place. This is another improvement over that of 1967 which was put at 175. In 1978, rural Kenya had 532 dispensaries. This is yet another improvement over that of 1967 put at 378 dispensaries. The data sources and measures of health facilities utilized in this study are stated in Section 2.4.

Another important variable is agriculture. This was selected to proxy for rural income as agriculture is the mainstay of the Kenyan people.

One crucial aspect of agricultural development in Kenya is the availability of rainfall. This plays a leading influence on land use in Kenya. For this reason rainfall data have been used to determine the amount of good quality land in various districts in Kenya. The data is presented in Section 2.3.

The unrealiability, both in amount and expected time of arrival of the rains has various consequences. The consequences for this feature for health are obvious. Studies have shown that in every four out of five years only 15 percent of the country gets more than 760 mm. rainfall per annum (Ojany, 1974). This is the minimum figure for economical agriculture without any irrigation. Studies have also shown that the arrival times of the rains are unreliable. Obviously, this unreliability affects the planned preparation of agricultural land in anticipation of the rains. Consequently, the reliance of agriculture which is the mainstay of the Kenyan people is therefore made unsafe. As a result of this, poor harvests and low yields become common features in farming activities.

The determinants of climate in Kenya include such factors as latitude, relief, position in relation to the rest of the continent, the rain-bearing winds, the position of the main lakes and the Indian Ocean. Lake Victoria provides the reliable high rainfall of the West Kenya Highlands such as Kisii, Kericho and Kakamega highlands which receive more of this essentially convectional rainfall than the lower parts such as the Kano plains trough.

In other parts of the country, the main rains are explained by the S.E. Trade Winds.

The Kenyan soils are also associated with climate, relief and the underlying rocks. Observations have shown that Red Desert soils dominate much of the drier parts of North-Eastern Province and Latosolic soils are mainly found over much of the Taita-Garissa belt including the outer drier plains of the lower Tana. Regosolic and Lithosolic soils are found towards the north from Solai to the Sudan border.

Pockets of rich soils that form the backbone of Kenya's agriculture are to be found in Western Kenya, the Central Highlands and the Coastal belt. These observations indicate that the amount of good quality land is scarce in Kenya.

The data sources and measures for the availability of good quality agricultural land by district are discussed in Section 2.4.

The remaining variable, kilometres of roads is an important variable which has always been neglected by researchers on differential mortality studies. It is expected that the number of kilometres of roads is negatively related to the levels of infant and child mortality. Roads enable the transportation of various kinds of foods from one area to another or the sick to hospitals. The number of kilometres of roads per 1000 square kilometres for each district is presented in Section 2.4.

2.2 The 1979 Population Census

The 1979 census data have been relied upon heavily for estimates of several variables, namely: infant and child mortality rates by district and by women's education; total fertility rates by district; proportions of women with five or more standards of education; percent of the population urban and population density by district. The following is a description of data sources and measures of these variables.

2.2.1 Mortality Data

The principal measure of infant and child mortality, q(2), for each district, is based on the 1979 Kenyan census data on parity and survivorship of children born to women in the reproductive age groups.

The 1979 Kenyan census conducted inquiries about births and deaths having occurred in each household during a stated period. These retrospective data were collected for all women of reproductive ages and beyond and tabulated for five-year age groups, at least throughout the childbearing years. From these data estimates of q(2) for each district are obtained by the estimation technique described in Chapter III. This method used the responses of women in different age groups about the numbers of children who are still alive and the total number ever born. This gives the proportion dead by age of woman from which mortality estimates are derived.

If the census data are accurate then the resulting mortality estimates will also be accurate. However, reports on life time births generally suffer from serious under-reporting since older women, in particular, fail to report all the children born to them. Those children who died young many years before are especially likely to be overlooked. Another common deficiency of these data is the failure to distinguish clearly between women who did not report on the number of children they had born and those who reported having had no children.

Obviously, any omission of dead children will bias our estimates. There is considerable evidence from different sources that such data are subject to possibilities of considerable error, either in the direction of under-statement as a result of omissions or over-statement as a result of erroneous reporting of births and deaths which occurred outside the census period of reference. While reports on lifetime births by young women, say up to 25 to 30 years of age, have been found to be subject to relatively little under-statement, for older women the errors appear to increase with advancing age (W. Brass, 1968, p. 91).

With these qualifications in mind, the mortality levels based on the reports of women aged 20-24 were considered the most reasonable estimates that can be obtained from these limited data. The q(2) estimates based on these data are presented in Chapter V.

2.2.2 Fertility Data

To estimate the total fertility rates (TFR's) by district, the 1979 Census data has been utilized. This provides the average number of children ever born per woman by age of mother and information on children born during the 12 months preceding the census period by age of mother.

Brass fertility estimation method described in Chapter III uses these two types of data to obtain estimates of age-specific fertility rates and hence total fertility rates by district. These estimates of TFR have been used to proxy for higher parity births which are expected to be positively related to infant/child mortality rates. Table 2.2 presents the Brass estimates.

These results suggest that fertility rates are high among the districts in Western Nyanza and Central Provinces with low fertility in the Coast. Some districts in the Rift Valley and Eastern Province have high fertility rates.

2.2.3 Women's Education

The 1979 census also provides data on educational attainment. The census asks for the highest standard or form of education completed regardless of grades "skipped" or "repeated".

School enrolment in Kenya is classified by the following levels: primary, secondary and university. Since 1966 the primary level provides 7 years of education, each year classified as standards. Before 1966 this level provided 8 years of education similarly classified as standards. The secondary level includes 6 years of secondary, and higher education

TABLE 2.2 TOTAL FERTILITY RATES BASED ON AVERAGE NUMBER OF BIRTHS DURING THE PRECEDING YEAR AND AVERAGE NUMBER OF CHILDREN EVER BORN - KENYA - 1979 CENSUS

District/ Province	TFR Based on P_3/F_3	District/ Province	TFR Based on P_3/F_3
NYANZA		CENTRAL	8.81
Kisumu	7.49	Kiambu	8.34
Siaya	7.68	Muranga	8.80
South Nyanza	8.17	Nyeri	8.60
Kisii	9.90	Kirinyaga	9.16
RIFT VALLEY	8.47	Nyandarua	9.88
Laikipia	9.00	COAST	7.09
Narok	8.06	Mombasa	5.43
Kajiado	8.03	Kilifi	7.53
Turkana	3.77	Kwale	7.49
Samburu	6.91	Lamu	7.94
Nakuru	8.77	Taita Taveta	8.11
Baringo	8.87	Tana River	8.10
Kericho	9.00	EASTERN	8.49
Uasin Gishu	8.83		
Nandi	8.61	Embu	9.52
Trans Nzoia	9.13	Meru	8.15
Elgeyo Marakwet	7.95	Isiolo	6.69
West Pokot	8.17	Kitui	8.46
WESTERN	8.73	Machakos	8.81
		Marsabit	6.67
Kakamega	8.79	N. EASTERN	7.95
Bungoma	9.36		
Busia	7.76	Garissa	8.25
NAIROBI	5.45	Wajir	9.65
		Mandera	7.76

Source: Computer Printout

classified as Forms. Thus Form VI refers to sixth year at this level. After attainment of minimum conditions Form VI leavers are admitted to university or college for undergraduate studies or diplomas.

The percentages of women aged 15 years or over by educational attainment have been obtained for each district from the 1979 census data. A summary table showing the distribution of female adults literate is given in Appendix A. A literate person has been defined as one who has completed 5 or more standards of education (Anker and Knowles, 1977, p. 15). From these results it is clear that only four districts, (Nairobi, Mombasa, Kiambu and Nyeri) reported over 50 percent of their adult population and over 40 percent of their female adults having completed a minimum of standard five. Comparable proportions of adults literate for Kirinyaga, Muranga, Embu, Machakos, Meru, Kisii, Kisumu, Kericho, Laikipia, Nakuru, Trans Nzoia, Uasin Gishu, Bungoma, Busia and Kakamega districts were between 30 percent and 50 percent; and below 10 percent for Lamu, Tana River, Garissa, Mandera, Wajir, Samburu and Turkana districts. This tends to suggest that a big gap exists between the less educationally advanced districts and more advanced ones.

2.2.4 Urbanization

The United Nations Economic Commission for Africa (U.N.E.C.A.) has defined settlements with 20,000 or more inhabitants as urban (cf. U.N.E.C.A., 1968 and 1975). However, some national definitions in different countries specify or accept settlements with much smaller numbers as urban. In the case of Kenya recent censuses have treated centres of 2,000 or more as urban. The 1979 census, however, has included centres of 1,000 or more as urban.

Urbanization by district, as indicated in Table 2.3 varies below 1.0 percent of the total population, for Siaya and South Nyanza districts to about 100 percent for Nairobi and Mombasa. The table shows that there is uneven distribution among the districts.

TABLE 2.3 THE DISTRIBUTION OF URBAN POPULATION - 1979 CENSUS

District/ Province	Total Pop. (1979)	No. of Towns Reporting Pop. of 2000 persons or more	Urban Population	Percent Urban
NAIROBI	827,775	1	827,775	100.0
CENTRAL				
Kiambu	686,290	4	51,652	7.50
Kirinyaga	291,431	3	8,000	2.71
Muranga	648,333	2	17,477	2.70
Nyandarua	233,302	1	11,243	4.82
Nyeri	486,477	3	40,844	8.39
COAST				
Kilifi	430,986	4	34,212	7.99
Kwale	288,363	2	8,312	2.90
Lamu	42,299	2	10,607	25.24
Mombasa	341,148	1	341,501	100.00
Taita/Taveta	147,597	1	7,329	4.95
Tana River	92,401	1	5,348	5.80
EASTERN				
Embu	263,173	1	16,176	6.15
Isiolo	43,478	1	11,350	26.17
Kitui	464,283	2	6,724	1.45
Machakos	1,022,522	3	99,971	9.81
Marsabit	96,216	3	19,618	20.39
Meru	830,179	2	75,043	9.01
N. EASTERN				
Garissa	128,867	2	20,087	15.62
Mandera	105,601	2	16,750	15.88
Wajir	139,319	3	19,741	14.24
NYANZA				
Kisii	864,512	1	30,661	3.54
Kisumu	482,327	2	155,841	32.47
Siaya	474,516	1	4,005	0.85
S. Nyanza	817,601	3	15,761	1.93
RIFT VALLEY				
Narok	210,306	2	23,440	10.99
Samburu	76,908	2	12,488	16.25
Trans Nzoia	259,503	1	28,389	10.94
Turkana	142,702	5	19,348	13.56
Uasin Gishu	300,766	1	50,219	16.52

Cont'd .../ ...

District/ Province	Total Pop. (1979)	No. of Towns Reporting Pop. of 2000 persons or more	Urban Population	Percent Urban
West Pokot	158,652	2	4,855	3.06
Baringo	203,792	4	13,675	6.75
Elgeyo Marakwet	148,868	-	-	-
Kajiado	149,005	4	12,076	8.10
Kericho	633,348	3	37,758	5.94
Laikipia	134,529	1	19,085	14.19
Nakuru	522,709	6	132,594	25.38
Nandi	299,319	1	2,975	0.99
WESTERN				
Bungoma	503,935	3	44,841	8.91
Busia	297,841	1	24,980	8.32
Kakamega	1,030,887	2	35,344	3.42

Source: 1979 Provisional Census Results

In the Coast Province, the distribution shows a wide gap between Mombasa and the rest of the districts in the Province. Mombasa alone accounted for 81.17 percent of the total urban population of the Province. In Eastern Province, Machakos town accounted for 34.15 percent and Meru 29.39 percent, while in Nyanza, Kisumu accounted for approximately 71 percent of the total urban population, and Kisii 14.0 percent.

The Rift Valley Province shows a more dispersed pattern with Nakuru District reporting about 25.38 percent of its population as urban being the most urbanized district in the Province. Central Province shows uneven distribution with Nyeri having 8.39 percent of its population living in the urban centres being the most urbanized, and Muranga (2.70 percent) being the least urbanized in the provinces.

Western Province shows a balanced pattern. The three districts

(Kakamega, Busia and Bungoma) each has just over 20 percent of the provincial urban population.

2.2.5 Population Density

The 1979 census also provides the density of population by district. These are shown in Table 2.4. It is clear from these figures that the density was highest in the districts of Nyanza, Western and Central Provinces. The densities in the Western Kenya districts were above 160 persons per square kilometre. Kisii (395), and Kakamega (294) had the highest overall. The high population densities of Western Kenya coincides with high potential lands, bordering Lake Victoria.

In the high agricultural districts of Kericho, Nandi, Uasin Gishu and Trans Nzoia in the Rift Valley, population densities range from 80 to 160 persons per square kilometre.

The zone of concentration extends from Nairobi north-eastwards to the Nyambeni Hills in Meru district. This is known to be one of the most settled parts of rural Kenya carrying densities comparable to those of Southern Asia and other parts of the world. The thickest concentrations are to be found in Kiambu, just to the north of Nairobi.

A vast region of Kenya is sparsely populated by scattered members of the pastoral groups in the Rift Valley, Eastern, North-Eastern and Coast Provinces. Overall densities in the districts found in these areas are generally less than 10 persons per square kilometre. Most of these districts are generally arid.

TABLE 2.4 DISTRIBUTION OF POPULATION (DENSITY) - KENYA - 1979 CENSUS

District/ Province	Population	Sq. Km.	Density
NAIROBI	827,775	684	1,210
CENTRAL	2,345,833	13,173	178
Kiambu	686,290	2,448	280
Kirinyaga	291,431	1,437	202
Muranga	648,333	2,476	261
Nyandarua	233,302	3,528	66
Nyeri	486,477	3,284	148
COAST	1,342,794	83,040	16
Tana River	92,401	38,694	2
Kilifi	430,986	12,414	34
Kwale	288,363	8,257	34
Lamu	42,299	6,506	6
Mombasa	341,148	210	1,622
Taita/Taveta	147,597	16,959	8
EASTERN	2,719,851	155,759	17
Meru	830,179	9,922	83
Embu	263,173	2,714	96
Isiolo	43,478	25,605	1
Kitui	464,283	29,388	15
Machakos	1,022,522	14,178	72
Marsabit	96,216	73,952	1
NORTH-EASTERN	373,787	126,902	2
Wajir	139,319	56,501	2
Garissa	128,867	43,931	2
Mandera	105,601	26,470	3
NYANZA	2,643,956	12,525	211
South Nyanza	817,601	5,714	143
Kisii	864,512	2,196	395
Kisumu	482,327	2,093	230
Siaya	474,516	2,522	188
RIFT VALLEY	3,240,402	163,883	19
West Pokot	158,652	9,090	17
Kajiado	149,005	19,605	7
Baringo	203,792	9,885	30
Elgeyo Marakwet	148,868	2,279	65
Kericho	633,348	3,931	161
Laikipia	134,524	9,718	13
Nakuru	522,709	5,769	90

Cont'd .../...

District/ Province	Population	Sq. Km.	Density
Nandi	299,319	2,745	109
Narok	210,306	16,115	13
Samburu	76,908	17,521	4
Trans Nzoia	259,503	2,078	124
Turkana	142,702	61,768	2
Uasin Gishu	300,766	3,378	89
WESTERN	1,832,663	8,196	223
Kakamega	1,030,887	3,495	294
Bungoma	503,935	3,074	163
Busia	297,841	1,626	183

Source: 1979 Provisional Census Results, Kenya.

2.3 Limitations of the Census Data

This section examines the age and sex distribution of the population by district as reported in the 1979 census. The census reports of total numbers of live births and births during the preceding year tabulated by age of mother can only be useful if the respondent's age is reported with a reasonable degree of accuracy. For this reason, the analysis of the reliability of age and sex data is imperative.

2.3.1 Age Reporting

Information on age obtained from Kenyan censuses have in many cases suffered from misreporting. This fact is related to several factors of the Kenyan society. First the low level of education in most parts of the country hinders accurate reporting. Secondly, most Kenyan cultures do not give any importance to age. Another reason is that birth registration in Kenya occurs in a small scale and therefore few people (especially those over age 20 or 30) have birth certificates which enable them to recall their birth date.

To test the accuracy of age-sex data the United Nations index has been employed.

2.3.2. Accuracy of the Regional Age-Sex Data

Age-specific sex ratios provide the best indication of age misreporting only in the absence of extensive migration. Populations with poor age statement tend to exhibit sex ratios which change drastically from one age group to the next. Appendix B exhibits the age-specific sex ratios for all the districts from the 1979 census. From these results we note that there exists a preponderance of women for most of the age groups.

A better picture of the actual situation is obtained by comparing the Sex Ratios (SR) observed per age categories with the African Standard model. We would expect sex ratios of 94, 92 and 90 for age groups 50-54, 55-59, and 60-64. But the actual sex ratios for those over 45 are clearly too high. This suggests that women aged over 30 or 35 years tend to underestimate their ages. It can also be observed that females are more numerous than males in the age group 15-19. This suggests that there was an overestimation of ages by women aged 10-14 for most districts. There is also the possibility that men may have exaggerated their ages.

Generally, one would infer from these results that there is an excess of women reported as aged 20 to 40 years. Thus women were apparently transferred to the childbearing period from both under and above this age. This is consistent with the African pattern (Brass, et. al., 1968, p. 45).

TABLE 2.5 UNITED NATIONS INDICES

District	Sex Ratio Scores	Age Ratio Scores		Joint Score
		Males	Females	
1. Baringo	5.16	5.34	4.19	25.01
2. Bungoma	5.67	4.89	5.38	27.28
3. Kiambu	6.18	6.74	4.34	27.62
4. Elgeyo Marakwet	7.10	7.15	3.34	31.79
5. Kakamega	7.40	5.73	4.19	32.32
6. Taita/Taveta	5.87	9.65	5.35	32.61
7. Meru	7.42	5.71	5.42	33.39
8. West Pokot	6.90	7.18	6.46	34.34
9. Trans Nzoia	8.44	4.75	5.02	35.09
10. Kericho	7.97	7.66	4.73	36.30
11. Laikipia	7.31	8.34	6.52	36.79
12. Busia	7.88	6.79	6.46	36.89
13. Kisumu	9.48	5.00	4.42	37.85
14. Muranga	8.03	8.65	5.15	37.89
15. Nakuru	9.08	6.26	5.79	39.29
16. Nyeri	7.34	11.67	6.50	40.19
17. Nandi	8.88	7.34	6.79	40.77
18. Kirinyaga	8.14	8.64	9.89	42.95
19. Uasin Gishu	10.81	6.98	4.04	43.45
20. Kisii	9.00	8.42	6.05	45.58
21. Turkana	10.19	9.59	6.02	46.18
22. Narok	11.16	6.29	6.09	45.86
23. Embu	9.41	8.94	8.76	45.93
24. Samburu	10.14	8.64	6.89	45.95
25. Nyandarua	9.58	9.05	8.50	46.29
26. Kwale	10.91	6.72	6.98	46.43
27. Kajiado	12.38	4.09	5.53	46.76
28. Siaya	10.99	9.68	5.11	47.76
29. Kilifi	10.86	8.10	7.10	47.78
30. South Nyanza	12.23	9.76	5.18	49.53
31. Mombasa	12.48	8.72	7.25	53.41
32. Machakos	9.58	15.54	12.81	57.09
33. Kitui	8.53	13.72	18.49	57.80
34. Tana River	17.52	4.11	15.31	71.98
35. Marsabit	10.42	17.11	25.74	74.11
36. Isiolo	20.30	12.08	26.74	99.72
37. Lamu	19.85	14.27	29.06	102.88
38. Nairobi	36.04	10.03	6.87	125.02
39. Wajir	11.53	42.35	48.25	125.19
40. Mandera	20.37	38.39	52.17	151.67
41. Garissa	26.55	23.31	36.40	139.36

N.B. These figures are based on the 1979 Population Census, By comparing the different districts it can be observed that there are large variations in their joint scores. The regional scores range from 25.01 for Baringo to 139.36 for Garissa. Except in the cities (Nairobi and Mombasa), these differences are too high to be accounted for by migration. They must represent big differences in the quality of age reporting.

In interpreting the quality of data using U.N. index, it should be noted that the lower the index, the better is the quality of age data. Thus on the basis of the computed U.N. Joint Score Indices (Table 2.5, column 5), data for Baringo District were more reliable than for any other district. On the other hand, the age data for Mombasa, Machakos, Kitui, Tana River, Marsabit, Isiolo, Lamu, Nairobi, Wajir, Mandera and Garissa districts have a U.N. Joint Score of over 50.

Since no age graduation has been undertaken on the 1979 census data, it is emphasized, therefore, that caution needs to be exercised when interpreting indices derived from the census age data - like infant/child mortality estimates, total fertility rates and the percentage of women literate which are based on the age distribution of women.

2.4 Other Sources of Data

2.4.1 Malaria

Malaria data were obtained from the Ministry of Health (Health Information Bulletin, 1980). This provides the number of all out-patient cases reported in hospitals recorded by disease and by district for the period January to July 1980. From these numbers percentages of outpatient cases who were malaria were computed. These are presented in Table 2.6. Provincial means were taken for districts with no available data.

TABLE 2.6 PROPORTION OF OUT-PATIENT CASES WHICH ARE MALARIA

District/ Province	Percent Malaria Cases	District/ Province	Percent Malaria Cases
NAIROBI	-		
COAST	22.39	NYANZA	29.69
Kilifi	26.09	Kisii	20.91
Kwale	23.79	Kisumu	34.71
Lamu	17.55	South Nyanza	31.56
Mombasa	18.29	Siaya	32.62
Taita/Taveta	23.93	WESTERN	30.00
Tana River	28.22	Busia	27.60
CENTRAL	6.77	Bungoma	30.38
Kiambu	4.53	Kakamega	31.03
Muranga	11.29	RIFT VALLEY	13.84
Kirinyaga	14.35	Uasin Gishu	19.81
Nyandarua	1.74	Kericho	14.92
Nyeri	1.35	West Pokot	23.63
EASTERN	18.76	Nakuru	9.16
Embu	16.67	Baringo	16.23
Kitui	24.98	Elgeyo Marakwet	13.23
Machakos	19.63	Samburu	14.08
Meru	15.71	Trans Nzoia	17.50
Isiolo	18.76	Turkana	13.84
Marsabit	18.76	Laikipia	5.97
NORTH-EASTERN		Nandi	13.84
Garissa	23.21	Kajiado	12.70
Wajir	16.42	Narok	13.71
Mandera	19.82		

Source: Health Information Bulletin, Ministry of Health, Kenya, 1980.

A look at these data shows that malaria is generally prevalent in the districts of Western, Nyanza and Coast Provinces. Kisumu district ranks highest with 34.71 percentage cases which are malaria. These figures also suggest that districts in the Rift Valley, Central, Eastern and North-Eastern Provinces are less malarious, reporting less than 30 percent out-patient cases which are malaria. Thus malaria prevails in the districts bordering Lake Victoria and those nearer to the Indian Ocean coast. The least malarious district in Kenya as suggested by these figures is Nyeri in the Central Province, reporting just 1 percent of the outpatient cases which are malaria. This also happens to be the lowest mortality region in the country. (Table 4.1).

2.4.2. Hospital Beds and Health Facilities

Two basic indicators of health have been used in this study: the number of government hospital beds (including cots) per 1,000 persons (1978) and the number of persons per health facility for each district. The Ministry of Health is the only source of data on these measures. The Ministry of Health, in determining which districts have the highest need for improvement and in assessing the utilization of these facilities also uses these parameters (M.O.H., 1978, p. 54).

As indicated in Table 2.7, the distribution of government hospitals and beds by district varies considerably. There is a heavy concentration in Nairobi and Mombasa (which also serve as referral centres), and a scarcity of beds in the districts of the North-Eastern Province. Putting these two extremes aside, it can be observed that of the remaining 39 districts, Kakamega district is the lowest on the scale with 0.26 beds for every 1000 persons, while Lamu is highest with 5.30.

TABLE 2.7 DISTRIBUTION OF GOVERNMENT HOSPITALS AND BEDS BY PROVINCE AND DISTRICT - KENYA, 1978

District/ Province	Population in 1978 (000's)	Hospitals	Hospital Beds and Cots	
			No. of Beds and Cots	Number Per 1000 Persons
NAIROBI	818	4	3,702	4.52
CENTRAL	2,237	11	1,866	0.83
Kiambu	636	4	590	0.92
Kirinyaga	287	1	199	0.69
Muranga	585	2	373	0.64
Nyandarua	240	1	217	0.90
Nyeri	489	3	487	1.00
COAST	1,285	15	1,797	1.40
Kilifi	400	2	149	0.37
Kwale	272	3	178	0.65
Taita/Taveta	140	3	156	1.11
Lamu	20	3	106	5.30
Tana River	62	2	168	2.71
Mombasa	391	2	850	2.17
EASTERN	2,503	11	1,437	0.57
Embu	256	2	181	0.71
Isiolo	33	1	43	1.30
Kitui	432	2	216	0.50
Machakos	926	3	623	0.67
Marsabit	56	2	135	2.41
Meru	799	1	239	0.30
NORTH-EASTERN	272	3	364	1.34
Garissa	71	1	167	2.35
Mandera	103	1	65	0.63
Wajir	97	1	132	1.36
NYANZA	2,958	6	1,558	0.53
Kisii	927	2	442	0.48
Kisumu	573	2	590	1.03
Siaya	515	1	227	0.44
S. Nyanza	944	1	299	0.32
RIFT Valley	2,933	25	2,709	0.92
Baringo	172	1	61	0.35
Elgeyo Marakwet	197	1	72	0.36
Kajiado	114	3	217	1.90
Kericho	719	3	223	0.31

Cont'd .../...

District/ Province	Population in 1978 (000's)	Hospitals	Hospital Beds and Cots	
			No. of Beds and Cots	Number Per 1000 Persons
Laikipia	74	1	79	1.07
Nakuru	401	7	1,209	3.01
Nandi	280	2	129	0.46
Narok	148	1	132	0.89
Samburu	89	1	59	0.66
Trans Nzoia	190	1	195	0.97
Turkana	166	2	52	0.31
Uasin Gishu	283	1	141	0.50
West Pokot	98	1	150	1.53
WESTERN	1,870	4	773	0.41
Kakamega	1,096	1	285	0.26
Bungoma	514	1	160	0.31
Busia	259	2	328	1.27

Source: Ministry of Health, 1979 (Unpublished data).

Since Nairobi and Mombasa hospitals serve as principal referral centres, they treat patients from other districts. Thus their bed/population ratios are exaggerated.

The distribution of health facilities (health centres, health sub-centres and dispensaries) for the year 1978 is shown in Table 2.8. These coverage ratios exclude Church and other private institutions.

The baseline data (population size and the number of health facilities) were derived from the first draft for Health Development Plan 1979-1983 (M.O.H., Jan. 1978).

From Table 2.8 it can be seen that the distribution of health facilities by district varies considerably. Turkana district with a ratio of one health facility per 83,000 persons is the least equipped. Lamu is the only better-off district with a ratio of 1:2000.

TABLE 2.8 POPULATION/HEALTH FACILITY RATIOS - KENYA

District/ Province	Population (1978) (000's)	Number of Rural Health Facilities				Population/ Health Facility Ratios
		HC	HSC	D	Total	
NAIROBI						
CENTRAL						
Kiambu	636	14	2	6	22	1:30,000
Kirinyaga	287	4	1	23	27	1:10,600
Muranga	585	7	2	31	40	1:14,600
Nyandarua	240	6	2	12	20	1:12,000
Nyeri	489	7	-	29	36	1:13,600
COAST						
Kilifi	400	3	3	26	32	1:13,000
Kwale	272	2	-	18	20	1:13,600
Taita/Taveta	140	4	1	12	17	1:8,200
Lamu	20	2	-	8	10	1:2,000
Tana River	62	2	-	9	11	1:5,600
Mombasa						
EASTERN						
Embu	256	2	2	18	22	1:11,600
Isiolo	33	2	-	4	6	1:5,500
Kitui	432	7	1	21	29	1:15,000
Machakos	926	8	1	34	43	1:21,500
Marsabit	56	-	-	6	6	1:9,300
Meru	799	8	-	27	35	1:23,000
NORTH-EASTERN						
Garissa	71	3	-	4	7	1:10,000
Mandera	103	2	-	1	3	1:34,300
Wajir	97	-	1	8	9	1:10,800
NYANZA						
Kisii	927	6	1	15	22	1:42,000
Kisumu	573	5	2	9	16	1:36,000
Siaya	515	4	1	16	21	1:24,500
South Nyanza	944	10	2	18	30	1:31,500

Cont'd .../...

District/ Province	Population (1978) (000's)	Number of Rural Health Facilities				Population/ Health Facility Ratios
		HC	HSC	D	Total	
RIFT VALLEY						
Baringo	172	5	-	28	33	1:5,200
Elgeyo Marakwet	197	3	-	7	10	1:19,000
Kajiado	114	5	1	14	20	1:5,700
Kericho	719	5	2	32	39	1:18,400
Laikipia	74	3	-	5	8	1:9,200
Nakuru	401	8	4	32	44	1:9,100
Nandi	280	4	2	7	13	1:21,500
Narok	148	6	1	10	17	1:8,700
Samburu	89	2	-	2	4	1:22,000
Trans Nzoia	190	4	1	5	10	1:19,000
Turkana	166	1	-	1	2	1:83,000
Uasin Gishu	283	5	1	15	21	1:13,500
West Pokot	98	3	-	4	7	1:14,000
WESTERN						
Bungoma	514	7	1	6	14	1:36,700
Busia	259	5	-	4	9	1:28,800
Kakamega	1,096	19	-	5	24	1:45,700

N.B. HC = Health Centres,
HSC = Health Sub-Centres
D = Dispensaries

Source: Ministry of Health, 1978.

2.4.3 Agricultural Land Potential

Rainfall data have been used to determine the amount of good quality land by district (Statistical Abstract, 1979, p.101; I.L.O., 1972, p.35).

Table 2.9 shows the estimated availability of good quality agricultural land per person by district in 1979. The number of hectares of high potential land per person has been used as a crude measure of rural income. This measure was found on the basis of three rainfall categories as follows:

TABLE 2.9 AGRICULTURAL LAND PER PERSON, KENYA - 1979

District	Population	Hectares of High Potential Agr. Land ('000 Hectares)	Land Per Person
Nairobi	827,775	16	0.019
Kiambu	686,290	) 386	) 0.289
Muranga	648,333	)	)
Kirinyaga	291,431	98	0.336
Nyandarua	233,302	265	1.136
Nyeri	486,477	160	0.329
Kilifi	430,986	104	0.241
Kwale	288,363	126	0.437
Lamu	42,299	7	0.165
Mombasa	341,148	21	0.062
Taita/Taveta	147,597	42	0.284
Tana River	92,401	73	0.790
Embu	263,173	66	0.251
Isiolo	43,478	-	-
Kitui	464,283	67	0.144
Machakos	1,022,522	125	0.122
Marsabit	96,216	4	0.042
Meru	830,179	214	0.290
Garissa	128,867	-	-
Mandera	105,601	-	-
Wajir	139,319	-	-
Kisii	869,512	220	0.253
Kisumu	482,327	) 432	) 0.451
Siaya	474,516	)	)
South Nyanza	817,601	566	0.692
Baringo	203,792	166	0.814
Elgeyo Marakwet	148,868	104	0.699
Kajiado	149,005	22	0.148
Kericho	633,348	380	0.600
Laikipia	134,524	130	0.966
Nakuru	522,709	291	0.557
Nandi	299,319	234	0.782
Narok	210,306	908	4.318
Samburu	76,908	140	1.820
Trans Nzoia	259,503	208	0.802
Turkana	142,702	12	0.084
Uasin Gishu	300,766	327	1.087
West Pokot	158,652	103	0.649
Bungoma	503,935	253	0.502
Busia	297,841	163	0.547
Kakamega	1,030,887	325	0.315

Source: Column 2, Kenya Population Census, 1979
Column 3, Statistical Abstract, 1979, Table 80.

(1) High Potential: Annual rainfall of 857.5 mm. or more (over 980 mm. in Coast Province)

(2) Medium Potential: Annual rainfall of 735 mm - 875.5 mm. (735 mm. - 980 mm. in Coast Province and 612.5 mm. - 857.5 mm. in Eastern Province).

(3) Low Potential: Annual rainfall of 612.5 mm. or less.

Rainfall data collected from over 100 stations in Kenya were used and the calculation was done on the assumption that 5 hectares of medium-potential land and 100 hectares of low-potential are equivalent to 1 hectare of high-potential land. Obviously, this is a crude weighing system. However, it is considered adequate for establishing broad orders of magnitude.

It is clear from these data that the amount of good quality agricultural land potential is scarce in Kenya. The districts with virtually no land of high or medium potential agricultural land are Garissa, Wajir, Mandera and Isiolo. The whole of Western Province has a high potential agricultural land.

2.4.4 Kilometres of Roads

Roads per surface area is one of the most important indicators of economic development. Districts with more network of road development obviously have higher economic activity and consequently income than the less developed districts.

The number of kilometres of roads per 1000 square kilometres as reported in a recent publication of the International Labour Office (ILO, 1972), has been selected as an indicator of economic development at the district level.

Looking at the data (Appendix C, column 5), it appears that few districts are still economically under-developed. It can be observed that there are remarkable disparities among the disricts in the number of kilometres of roads. The data for Nairobi was not given. Districts in Central Province appear to be better-off with Kiambu having the highest number of kilometres of roads (267/1000) while districts in North-Eastern Province are worse-off. Mandera district had the least number of kilometres of roads (11/1000 Km^2). It appears that districts with higher per capita agricultural potential land and greater population densities contain more network of roads.

CHAPTER III

ANALYTICAL MODELS AND TECHNIQUES

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ANALYTICAL MODELS AND TECHNIQUES

3.1 Introduction

Models and techniques of analyzing mortality data to study associations between mortality levels and its determinants depend largely on the type of data available. Traditionally, the approach has been to use the census (stock data) as the denominator and vital registration (flow data) as the numerator in analyzing differential mortality.

In the more developed countries, the linking of census and death records has been a decisive step forward in the methodology of mortality analysis by socio-economic status. There are three approaches now being employed by these countries (WHO, 1980b). These are outlined below:

(1) The Flow-Back Studies (Record Linkage/Retrospective)

These kinds of studies are presently being conducted in the United States of America. A feature of these studies is that a sample of Death Certificates was drawn within a period of three to four months after the 1960 Census. Linkage was made with the 1960 Census returns as regards criteria such as education, income and occupation. A recent refinement of this approach is the retrospective collection of details about the deceased person from his or her relatives.

(2) The Prospective Studies

Prospective studies are currently being undertaken in France and the Scandanavian countries. To illustrate how these studies are being conducted, two examples may be mentioned from France. The first of these examples is one in which birth certificates have been linked with death certificates for a sample of births. This makes it possible to obtain very accurate infant mortality rates per generation for each socio-occupational category. The second example is a cohort study in which a sample of individuals aged 30-64 years from the 1954 Census was classified once and for all into socio-economic categories and matched with their death certificates. The sample is being followed up at all ages until all the subjects concerned die.

(3) The Longitudinal Studies

These type of studies were started in the United Kingdom in 1971. The Office of Population Census and Surveys in London carried out a longitudinal study in 1971 designed to cover continuously approximately 1 percent of the population of England and Wales. To a sample drawn from the 1971 Census are added subsequent births and immigrants arriving since the 1971 Census. The events at which information about the sample members is recorded include censuses, births of children, deaths of infants, deaths of spouses, cancer registration, and death.

Another valuable source of data on socio-economic conditions presently being used in a few countries is data obtainable from population registers that exist in these countries. Data of this kind have been used in certain Scandinavian countries for the analysis of differential mortality.

The above approaches all require an elaborate system of record-keeping, updating and retrieval which are unavailable in many countries. In the developing world the only useful data now available are those derived from the censuses, sample surveys and sample registration schemes.

According to Clairin, one of the most difficult problems for a demographer in the developing countries, and particularly in sub-Saharan Africa, is the estimation of mortality levels and life table functions (Clairin, R., 1968). In Kenya, such a problem becomes increasingly difficult when one attempts to estimate mortality levels and life table functions at the district level. As long as no complete vital registration system exists in these areas, precise information in this field is unobtainable. It is therefore necessary to obtain the best possible approximations.

Difficulties arise in using direct methods for the estimation of differential death rates in the developing countries. Underreporting, for example, introduces differential biases with respect to sex of the deceased person, the educational status of the respondent, or his or her age and leads to spurious findings. One possible explanation for the anomaly in the mortality data is that respondents may be reluctant to talk about death, because this may invoke bad spirits. Thus it is possible that when asked to name and describe (sex, when born, when died) each child who has died, respondents do not frequently provide this information, but when asked to give the number of children who have died there is less reticence. Researchers in the developing countries, therefore, usually employ some indirect approaches.

Indirect methods frequently use only one source of information, on the number of children ever born and the children surviving, by age of mother, orphans by age and other characteristics. The census also contains information on the specific socio-economic characteristics of the parents of the children and of the household and tabulations are made for the differential analysis of mortality.

The indirect methods commonly employed are valid especially for the estimation of child mortality between birth and the ages of two, three, or five years. The census provides child survival by district. The reported proportions of children surviving to woman aged 20-24 years were converted into estimates of the probability of a birth surviving to age 2 years, q(2) using a technique developed by William Brass (Brass, et. al., 1968, p. 125).

The census information is also another source of data on adult mortality. The respondents are required to state whether or not his or her father and mother are still alive. In the same way as estimates of infant and child mortality may be derived from proportions of children dying and surviving when tabulated by age of mother, so may estimates of adult mortality be derived from proportions of surviving parents, tabulated by age group of respondent. In the present analysis, however, only child survivorship data have been utilized to study reported mortality differentials.

3.2 Brass's Technique for Estimating Childhood Mortality

In Kenya, like in other developing countries, the data derived from vital registration are of too poor a quality to permit the estimation of the levels of child mortality. Thus it is only feasible to estimate mortality from census data. In the 1969 and 1979 Kenyan Censuses, women have been asked to report the total number of children ever born to them, and in addition, the number of children still alive. It has long been established that the proportion surviving depends on the level of infant and child mortality. The variations in the proportions surviving within the population enumerated can be considered as an index of differential mortality. An important method of estimating child mortality from census data, attributable to Brass (1964); Brass, et. al., (1968), requires information on the number of children surviving among children ever born to women aged 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49 and so on. This method converts proportions surviving and proportions dead among the children ever born to women in different age groups into conventional measures of mortality. Under conditions of unchanging fertility and mortality, Brass's estimation procedure makes it possible to estimate the proportion ever born who survive to age 1, 2, 3, 5, 10, 15, ...35 from the proportions reported as surviving among children ever born to women in the different child-bearing age groups.

With regard to the variability of the estimates q(1), and estimates beyond q(10) cannot be taken seriously as precise figures. q(1) is an especially untrustworthy figure, and estimates beyond q(10) are based on the memory of remote events by women whose responses are not representative of current mortality experience. Thus the estimates of q(2), q(3), and q(5) have often been accepted as minimum indications of the level of recent infant and child mortality. For this analysis, therefore, the estimates based on q(2) are widely used.

3.2.1. Mathematical Derivation

For each 5-year age group of females in the different age groups, the complement of the ratio of surviving children ever born is the proportion of children who have died:

$$Q_x = 1 - \frac{S_i}{P_i}$$

where:

S_i are the surviving children reported by mothers in the ith 5-year age interval, the first interval being 15-19;

P_i are the children ever born reported by mothers in the ith age group; and

Q_x is the proportion not surviving from birth to an age x.

Under model conditions, the proportions of non-survivors can be used to approximate the probability of children dying before age x - the function q(x) of a life table.

The procedure depends on the approximate equality of q(1) and Q_1, q(2) and Q_2, ... q(35) and Q_{10} when the fertility and mortality schedules are "standard" ones with age patterns roughly like those found in the African populations. These approximate equalities are affected by variations that occur in the age pattern of fertility more strongly than variations occurring in the age pattern of mortality. Brass has provided factors which make it possible to estimate the q(x) values from the Q_x values, for fertility schedules with early or late child-bearing as well as with a mean age at childbearing of about 28 years. There are three indices of early versus late child-bearing.

(a) The ratio of the average parity of women 15-19 to the average parity of women 20-24 - i.e. P_1/P_2;

(b) The mean age of the fertility schedule ($\bar{m}$);

(c) The median age of the fertility schedule ($\bar{m}'$), estimated as the age x such that $P_x = \frac{1}{2}P_{50}$

Index (a) is a measure of when fertility starts and how it rises with age. Thus it is used to obtain the multipliers needed to convert Q_1 into q(1), Q_2 into q(2), and Q_3 into q(3). Indexes (b) and (c) are measures of the age around which child-bearing centres. At ages much above the mean of the fertility function, all births occurred at the mean age of childbearing. So $\bar{m}$ or $\bar{m}'$ are used for obtaining factors to use with Q_4 to Q_{10}.

The multiplying factors can, therefore, be obtained by either of two options outlined below:

Option 1: Mean or Median Age of Fertility Schedule ($\bar{m}$ or $\bar{m}'$) is Known

The factors for the age group 15-19, 20-24, and 25-29 are obtained by interpolating the table presented according to the particular value of K where:

$$K = \frac{P_1}{P_2}$$

The factors for the remaining age groups are obtained from the same table, but by interpolating between two $\bar{m}$ ($\bar{m}'$) values in the table according to the particular value of the mean age of the fertility schedule that pertains to the population.

Option 2: $\bar{m}$ and $\bar{m}'$ are Unknown

For all the age groups the factors are obtained by interpolating in the table for the actual value of K.

In both of these methods, the interpolation gives a set of correlation factors for each particular q(x) such that:

$$q(x) = Q_x . f_x$$

where:

f_x is the value interpolated from the table for the particular age x.

For the purpose of the regression analysis (see Chapter IV), the values of q(2) (the probability of dying before reaching age 2 years) for each district were chosen as the best estimates of infant/child mortality. The reasons behind this choice are mentioned in the following section.

3.2.2. Assumptions and Limitations of Brass's Mortality Estimation Method

The ideal conditions that would make the computation of mortality estimations accurate are as follows:

(1) The age specific fertility schedule has been approximately constant in the recent past (at least for the younger women), and the approximate form of the schedule is known;

(2) Infant and child mortality rates have been approximately constant in the recent years;

(3) There is no powerful association between age of mother and infant mortality or between death rates of mothers and of their children;

(4) Omission rates of dead children and or surviving children are about the same in the reported numbers ever born;

(5) Age pattern of mortality among infants and children conforms approximately to the model life tables.

These conditions specified as ideal are seldom, if ever, completely fulfilled. Kenya has been maintaining a condition of rising birth rates and falling death rates in the recent years. However, the effect is not likely to be important, because fertility trends experienced in Kenya are gradual, and because the multiplying factors are not sensitive to small differences in P_1/P_2.

Another possible source of bias is the association between infant mortality on the one hand and age and parity of the mother on the other. It has been established that in many populations having reliable records the mortality of the first born, and of children born to teenage women, is substantially higher than mortality of other children (Brass, et. al., 1968). This difference, if also prevalent in Kenya, would tend to make the q(1) estimated from Q_1 unrepresentatively high.

Assumption (4) above is a very unrealistic assumption since children who are dead tend to be much more omitted or underestimated than those who have survived. It is possible for older women to understate the number of children they have born due to memory failure. Another possible omission in the data on child survival is the omission of children who died shortly after birth. Respondents may not realize the need to report the birth of a child who did not live long enough to have a place in the household. Thus the retrospective reporting is subject to errors of memory and to errors arising from an omission to mentioning dead children, especially those just recently deceased. Overstatement may occur when women report miscarriages as "children" dead.

On the other hand, the reports of younger women are likely to contain only minor errors due to memory failure, because the events reported are recent and parity is low. Thus it has been observed that the accuracy of reporting the number of children ever born tends to vary inversely with the age of the woman. Brass and Coale made the following remarks while dealing with the African countries:

'The number of children ever born is reported with good accuracy

> by younger women. The events which the younger women are asked to recall have happened recently; the total births to each are typically not more than two or three so that the difficulties of counting large numbers in a non-numerative society do not arise; living children (and a higher proportion of children ever born to younger mothers will survive to the time of the census) will often be present at the interviews, and few will be omitted because they have grown up and left the household". (Brass, W., et. al., 1968, p. 91).

All the above reasons tend to single out the estimates of q(2) and q(3) as the most reliable estimates of child mortality. These estimates are to be regarded as minimum estimates of mortality since dead children are more likely to go unreported. This is the reason for selecting q(2) as a measure of child mortality in this analysis.

3.3 Brass Technique for Estimating Total Fertility Rates

The method, which was devised by Brass (1968), has been used to obtain estimates of total fertility rates for the districts. The methodology uses the average number of children ever born per woman by age of the mother reported in the census, and the pattern of age-specific fertility rates pertaining to the population. This pattern of fertility rates is obtained from the census information on children born during the preceding year.

The methodology assumes that the average number of children ever born by age of mother given in the census accurately represents the cumulative age-specific fertility rates of the female population up to age 29. In addition, this method also assumes that the pattern of age-specific fertility rates determined from the census is the actual pattern of the age-specific fertility rates in the population. The method cannot be used with confidence when:

$$_5b_{45} \geq \frac{(_5b_{25})^2}{_5b_{20}}$$

where:

$_5b_x$ is the average number of children ever born to women in age group (x, x+4).

A detailed explanation of this method can be found in Brass, et. al. (1968) and in the U.N. (1967) Manual IV. Only the mathematical derivation of this technique is given in the following section.

3.3.1 Mathematical Derivation

From the age-specific fertility rate pattern, the cumulative fertility pattern up to ages 20, 25, ..., 50 can be calculated as:

$$CF_{x+5} = \sum_{j = 15, 5}^{x} {}_5P\Phi_j$$

where:

$_5P\Phi_j$ is the pattern of the age-specific fertility rate for women in age group (j, j+4); and

CF_{x+5} is the cumulative fertility pattern up to age x+5.

The method calculates factors for adjusting the cumulative pattern (CF_{x+5}) to the level of fertility implied by the average number of children ever born ($_5b_x$).

These factors are calculated with the help of an age-specific fertility rate model distribution. The model uses a function with a fixed shape but with the possibility of determining the mean for each paritcular case. The function is:

$$f(x) = C.(x-s).(s+33-x)^2 \quad \text{for} \quad s \leq x \leq s + 33 \ (1)$$

where $f(x)$ is the fertility rate of women aged x years, s is the starting age of the reproductive period and C is a constant. The function $f(x)$ is taken as zero when x is outside of the age interval s to s+33.

The starting age of child-bearing is calculated as:

$$s = \bar{m} - 13.2$$

where :
$\bar{m}$ is the mean age of child-bearing.

By integrating the function (1) from s to a particular age t, the cumulative fertility up to that age can be obtained. The integral is:

$$F(t) = \int_s^t f(x)\, dx$$

$$= C.\left[\tfrac{1}{4}(s+33-x)^4 - 11(s+33-x)^3\right]_s^t$$

Therefore an annual 5-year age-specific fertility rate for the age group i, i+5 will be:

$${}_5f_i = \frac{1}{5}\left[F(i+5) - F(i)\right]$$

Similarly, by integrating $F(x)$ between two particular ages and dividing by the age interval, the mean number of children ever born per woman in the age interval is found:

$${}_nMC_i = \frac{1}{n}\int_i^{i+n} F(x)\, dx$$

$$= \frac{C}{n}\cdot\left[\frac{11}{4}(s + 33 - x)^4 - \frac{1}{20}(s + 33 - x)^5\right]_i^{i+n}$$

Adjustment factors for each age group can then be calculated as:

$$_5K_x = \frac{_5MC_x - F(x)}{_5f_x}$$

and the adjusted average cumulative fertility will equal:

$$_5ACF_x = CF_x + {_5K_x} \cdot {_5P\phi_x}$$

Finally, the age-specific fertility rate pattern can be corrected by either of the following options:

<u>Option I</u> $\quad {_5\phi'_x} = {_5P\phi_x} \cdot \frac{_5b_{20}}{_5ACF_{20}}$

<u>Option II</u> $\quad {_5\phi''_x} = {_5P\phi_x} \cdot \frac{_5b_{25}}{_5ACF_{25}}$

where:

$_5\phi'_x$ is the corrected age-specific fertility rate for age group x, x+4, according to Option I.

$_5\phi'''_x$ is the corrected age-specific fertility rate for age group x, x+4 according to Option II; and

$_5b_x$ and ACF_x are as defined earlier

3.3.2 <u>Comments</u>

The set of age-specific fertility rates have been obtained from the 1979 Census as the data on number of children ever born. However, this is not necessary. The set of rates can be from other censuses or from registration data as long as one believes that they represent the actual pattern of fertility.

The method assumes that fertility has been constant during the past 10-15 years. The method also assumes that both the fertility pattern given by the number of births per woman for the preceding year and the level of fertility per woman under age 30 given by the number of children ever born are accurate. In censuses and surveys where there is possibly extensive age misreporting, the fertility pattern and children ever born per woman could be biased and hence the results of this method would be questionable. Thus one should be careful in interpreting the estimates of total fertility rates for the districts that have been obtained from this method.

3.4 Other Analytical Methods

This study considers the differential importance of a number of macro factors for determining the level of child mortality. An attempt has been made to clarify, to some extent, the relative importance of key variables as differentials in the level of child mortality in Kenya. The use of multivariate regression framework has answered several questions. First, it has been possible to determine to what extent health facilities, available hospital beds, malaria prevalence, parity of births, kilometres of roads, agricultural potential of the land, population density, education and urbanization are significant predictors of mortality when they are considered in combination with each other. The multivariate frame-work was also employed in determining the extent to which the various factors are of greater or lesser importance as predictors of mortality in 1979 as compared with the results of 1969 obtained by Anker and Knowles in their analysis of mortality differentials.

The following discussion leads to the development of the Regression Model which has been utilized in this analysis.

3.4.1 The Regression Model

Most studies that have attempted to relate environmental factors and mortality only consider relationships between one single or, composite determining variable (predictor) and the dependent variable (criterion). Examples of the studies involving the relationship of environmental factors and childhood mortality are studies undertaken by Cook (1969), Collins, et. al., (1971), Ashford, et. al., (1973), Puffer and Serrano (1973), Kelly and Munnan (1974), Fuchs (1974), and Cohen (1975). However, as economic, social hygienic and demographic variables do not exist in isolation but are to be considered simultaneously, bivariate associations tell us nothing about the separate contributions of specific determining factors. Multivariate analyses of the relationship between environmental factors and childhood mortality and morbidity, therefore, have been undertaken, for example, by Shah and Abbey (1971), Fraser (1972), Weisbroad, et. al. (1973), Brooks (1975), Anker and Knowles (1976) and Kune (1979).

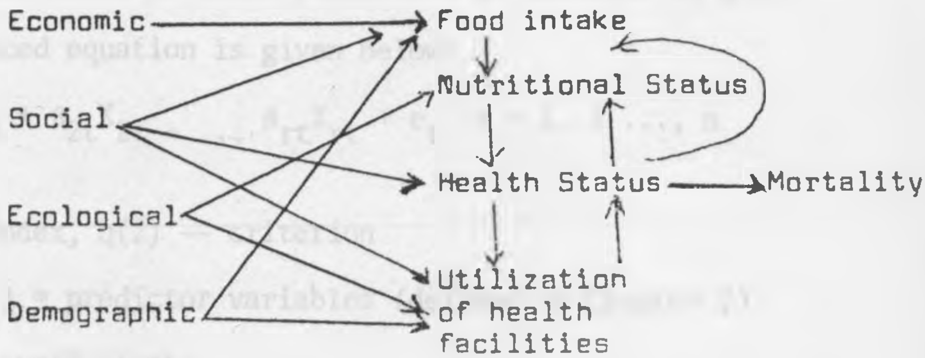
3.4.2 Model Specification

The correct specification of the relationships to be investigated has been found by structural model building. The causal modelling techniques that have been developed in various fields such as in biology (Wright, 1954), economics (Papandreau, 1962), the Social Sciences (Goldberger and Duncan, 1973) and Medicine (Cvjetanovic, 1971, 1972, Feldstein, 1973) provide a means of constructing structural models that depict the causal relationships that are hypothesized as existing among a system of interrelated variables.

Once a model has been formulated, a set of relationships can be written and the model parameters estimated. This set of equations permit predictions as to how changes in any one variable in the system affect all other related variables.

Figure 3.1 is a conceptual model stating the relationship between the independent and dependent variables in each district for purposes of clarity.

FIGURE 3.1 MODEL RELATING ECONOMIC, SOCIAL, HYGIENIC, ECOLOGICAL AND DEMOGRAPHIC CHARACTERISTICS TO MORTALITY IN THE DISTRICTS



The variables in the left-hand side of Figure 3.1 are considered to be influencing mortality through the intermediate variables (food-intake, nutritional status, health status and utilization of health services). Variations in these variables are assumed to be caused by variables outside the system considered. The intermediate are endogeneous variables determined by some combination of the variables in the system. However, many other factors are at work, like altitude and a lot of cultural influences.

The causal model depicted in Figure 3.1 can easily be written as a set of linear structural equations that represent the hypothesized relationships that underlie the model. It can be shown that the endogeneous variables can be expressed as functions of the exogeneous variables only. Such functions are called reduced-form equations (Goldberger, 1964).

In the present study we confine ourselves to one endogeneous variable only -- health status of child population as measured by q(2). The corresponding reduced equation is given below:

$$Y_t = \beta_0 + \beta_{1t}X_{1t} + \beta_{2t}X_{2t} + \dots \beta_{rt}X_{rt} + e_t,\ t = 1, 2 \dots, n$$

where Y_t = mortality index, q(2) -- criterion

$(X_{1t}, \dots, X_{rt})$ = predictor variables (defined in Chapter 2)

β_i = regression coefficients

e_t = error term (assumed to be normally distributed and independent).

For n observations (n = 41 districts) the model under consideration then becomes:

$$\begin{bmatrix} Y_1 \\ \cdot \\ \cdot \\ \cdot \\ Y_n \end{bmatrix} = \beta_0 \begin{bmatrix} 1 \\ \cdot \\ \cdot \\ \cdot \\ 1 \end{bmatrix} + \beta_1 \begin{bmatrix} X_{11} \\ \cdot \\ \cdot \\ \cdot \\ X_{1n} \end{bmatrix} + \beta_2 \begin{bmatrix} X_{21} \\ \cdot \\ \cdot \\ \cdot \\ X_{2n} \end{bmatrix} + \dots + \beta_r \begin{bmatrix} X_{r1} \\ \cdot \\ \cdot \\ \cdot \\ X_{rn} \end{bmatrix} + \begin{bmatrix} e_1 \\ \cdot \\ \cdot \\ \cdot \\ e_n \end{bmatrix}$$

By using ordinary least squares method one can compute for each value of "Y" the regression curve corresponding to each of the socio-economic variables. The computation of the regression coefficients of the equation and the correlation coefficients can be accomplished by using either matrix techniques or a computer. Because of the greater amount of data it was found necessary to use computer facilities. Hence, ICL package program SPSS (Statistical Package for Social Scientists) was used to obtain the regression coefficients and the partial correlation coefficients (Nie, N.H., et. al., 1975). This program also produced the best linear relationship for the variables.

In constructing the regression equation it is assumed that all variables (criterion and the predictors together) jointly follow a multivariate normal distribution. Strictly speaking, no real data follow a multivariate normal distribution exactly, for this is a mathematical model of prediction.

The simplest model commonly employed in the prediction of mortality levels, the bivariate or multivariate linear regression model, is inappropriate for handling the relationship among variables, if the variables involved do not follow a multivariate normal function. The assumption of multivariate normal density function implies linearity in the parameters (the homogeneity of the error variances) and the additivity of effects, i.e. the covariance matrix for the dependent variable employed is a constant function of the remaining variables of the system. Whenever there is a regression of the criterion upon one or more predictors, this condition of additivity is not always met, and the use of linear regression model is not strictly appropriate. However, in many cases the violation of this assumption is small in a practical sense and the linear regression model yields a tolerable approximation to the joint regression surface.

Where significant interaction effects are present the use of the linear regression model yields predicted values of the dependent variable which in effect do not "fit" any of the cases. Several methods have been proposed for handling such cases. Characteristics of these methods is the introduction of estimable interaction term into the regression whereby the criterion is expressed as a polynomial function in the predictors. The additivity effect and the homogeneity or error variance and additivity effect have been taken care of since there are no varied kinds of predictors as the predictors are uniform from district to district. There are socio-economic, urbanization, demographic, health and disease factors which are available for every district and there are reasonable measures for these variables. Hence there is a justification in assuming a statistical model of multi-variate regression where the equation is assumed linear in the independent variables.

Multiple regression analysis gives the values of the estimates of the regression weights and also their standard errors. Hence the predicted criterion, $(\hat{Y})$, can be obtained and the relationship between the predicted value and the actual value gives us the multiple correlation coefficient, R. This is obtained from the relation

$$R^2 = 1 - \frac{\Sigma(Y_i - \hat{Y}_i)^2}{\Sigma(Y_i - \bar{Y})^2}$$

where R^2 is the coefficient of determination. However, this is a theoretical way of obtaining multiple correlation coefficient. In most cases it is obtained in the manner outlined below:

The first step is to compute a predictor correlation matrix $\underline{R}$, i.e. the correlation matrix of the predictor variables. Then a vector $\underline{K}$ which contains the correlations between the predictor variables and the criterion is computed.

The required vector of beta weights β is then computed from the relationship

$$\underline{\beta} = \underline{KR}^{-1}$$

where R^{-1} is simply the inverse of the matrix R. In practice, therefore, the multiple correlation coefficient

R, is obtained from the relationship

$$R^2 = \underline{\beta}.\underline{K}$$

The square root of the inner product of vector $\underline{K}$ and vector $\underline{\beta}$ gives the multiple correlation coefficient.

For a given district with a given combination of predictor scores (X_1, X_2, ... , X_r), the actual criterion score Y of this district follows a normal distribution whose mean and standard deviation can be estimated by the predicted value of the criterion, ($\hat{Y}$), for that combination of predictor values using the regression equation obtained.

$$\hat{Y}_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \ldots \beta_r X_{rt}$$

3.4.3 Testing of Statistical Significance

The significance of a multiple correlation may be tested by calculating a variance ratio (F). It can also be tested by using the t-distribution whereby the t-value is found from:

$$t = \frac{R^2}{\sqrt{(1-R)^2/(n-2)}}$$

and this is compared with the table value of t found in the normal manner for (n-2) degrees of freedom. Another alternative is to calculate a Chi-square using an L criterion given by:

$$L = 1 - R^2$$

and the Chi-square is given by

$$X^2(rdf) = - n-1 - \tfrac{1}{2}(r+2) \log_e L$$

where r is the number of independent variables.

However, the variance ratio, F, is preferred to the t or the X^2-test. This is defined as the ratio of predicted to non-predicted variance. The predicted variance has degrees of freedom r and non-predicted variance has n-r-1 degrees of freedom. The variance ratio F, is, therefore, of the form:

$$F_r^{n-r-1} = \frac{R^2}{r} \bigg/ \frac{1-R^2}{n-r-1}$$

The F-distribution is used for testing the equality of two estimated variances. This problem frequently occurs when two variances are independently estimated and one wishes to test whether they are equal or not. Thus the F-test suggests that there exists a relationship between multivariate analysis of variance and multiple regression methods.

The t-distribution has been used to test the significance of the regression and correlation coefficients. For example, the t-value for a zero-order correlation is defined as:

$$t = \frac{r^2\sqrt{n-2}}{\sqrt{1-r^2}}$$

where r is the zero-order partial correlation coefficient, (n-2) the degrees of freedom. The estimated value of the regression constant, b($\hat{b}$) can be converted to the t-scale by using the relation:

$$t = \frac{\hat{b}}{S_{\hat{b}}}$$

where $\hat{b}$ is the estimate of the regression coefficient and $S_{\hat{b}}$ is its standard error.

The correlation coefficients are the measures of the regressions of the criterion "Y" on the predictor variables (X's). They also measure the degree of correlation between the criterion and the predictors. The correlation coefficient Y/X is given by:

$$r_{yx} = \frac{\frac{1}{n}\sum_{i=1}^{41}(Y_i-\overline{Y}) \sum_{r=1}^{9}(X_r-\overline{X})}{\sqrt{\frac{1}{n}\sum_{i=1}^{41}(Y_i-\overline{Y})^2 \cdot \frac{1}{n}\sum_{r=1}^{9}(X_r-\overline{X})^2}}$$

If there exists an exact linear relationship between the variables $r_{yx} = +1$ and the variables increase simultaneously, and $r_{yx} = -1$ when one variable increases and the other decreases. These are the two extreme cases. In general, r_{yx} can be positive or negative, with values lying between 0 and 1.

The signs and the relative magnitudes of the regression coefficients also indicate the nature and extent to which each of the determinants of mortality affect the level of mortality.

Other statistical concepts that have been reproduced in this analysis are as follows:

(1) The mean of the criterion variable

$$\overline{Y} = \frac{\sum Y_t}{n}, \quad t= 1, \ldots n \ (n = 41)$$

(2) The means of the predictor variables

$$\overline{X}_r = \frac{\sum_t X_{rt}}{n} \qquad \begin{array}{l} r = 1, \ldots 9 \\ t = 1, \ldots n \ (n = 41) \end{array}$$

(3) The standard deviation for the criterion variable:

$$\sigma(Y) = \sqrt{\frac{1}{n} \sum (Y_t - \overline{Y})^2}$$

and the predictor variable:

$$\sigma(X_r) = \sqrt{\frac{1}{n} \sum (X_{rt} - \overline{X})^2}$$

All these concepts are applied in the analysis chapter.

3.4.4. Some Problems of Multiple Regression

There are a number of drawbacks to the regression model that has been outlined above. First, we have the primary problem which occurs with the use of more explanatory (predictor) variables. This is the problem of multicollinearity defined as the intercorrelation of the independent variables. Multicollinearity arises when the independent variables overlap. Their individual influences and effects on the dependent variable as should be measured by the regression coefficient, become unreliable. The greater the overlap of the explanatory variables, the lower the reliability of the regression coefficients. The intercorrelation of the explanatory variables is measured by the simple correlation coefficient between these variables.

The objections raised against the use of Ordinary Least Squares (OLS) methods to estimate parameters of the linear regression model are:

- It can yield probabilities outside the acceptance 0-1 interval;
- The true probability relationship is more likely to be S-shaped than linear, approaching the probability values of zero and one asymptotically and that the
- OLS assumptions that the disturbance terms are:

  (a) Normally distributed with zero expectation,

(b) Homoskedastic, i.e. they have the same variance,

are violated.

Another problem and possibly the most serious problem in much statistical analysis is the lack of reliability of data. The degree of sophistication of this statistical model may be reduced by the fact that mortality data in Kenya is still far from satisfactory. Hence it is necessary that one remains cautious when interpreting any statistical results from the present analysis.

CHAPTER IV

DIFFERENTIAL MORTALITY IN KENYA

CHAPTER 4

DIFFERENTIAL MORTALITY IN KENYA

4.1 Introduction

In addition to providing estimates of the levels of infant/child mortality by district, the 1979 Census data has also been used to suggest differentials between districts. This chapter examines the 1979 mortality differentials through a multivariate analysis. The district level variables presented in Chapter II of this thesis are related to the existing levels of infant/child mortality. It is emphasized further that these mortality estimates should be treated with caution. The different estimates may be subject to over or under estimation for the reasons discussed in Chapters II and III. It is generally assumed throughout this chapter that the magnitude of potential errors is similar between the different districts. To the extent that this assumption holds, the differentials noted in this chapter should be reasonably accurate.

As an introduction to the explanation of mortality differentials which follow, this chapter begins by examining the variability in the levels of infant/child mortality by district. The geographic clustering of high and low mortality regions are examined and a few comments made about the quality of data that may explain some of the mortality levels.

4.2 Variability in Levels of Mortality By District

The data used in Table 4.1 for classifying the Kenyan districts according to the size-class of their infant and child deaths per 1000 births relate to the 1979 Census. Looking at Map 4.1, which shows the spatial distribution of early childhood mortality by district, one can distinguish five contrasting zones of early childhood mortality. At one extreme is Nyeri District in Central Province with the lowest level of early childhood mortality (49/1000). At the other extreme is the highest mortality zone consisting of three districts in the Nyanza Province (Kisumu, Siaya and South Nyanza), one in the Western Province (Busia), two in the Rift Valley Province (Baringo and West Pokot) and four from the Coast (Kilifi, Kwale, Lamu and Tana River).

Between these two extremes there are three zones: one zone, made up of three districts in Rift Valley (Laikipia, Kajiado and Samburu), four districts from Central Province (Kiambu, Muranga, Kirinyaga and Nyandarua) and two from Eastern Province (Embu and Meru), has the second lowest level of early childhood mortality (61-90); another zone consisting of two districts in Western Province (Kakamega and Bungoma), two districts in the Rift Valley Province (Turkana and Elgeyo-Marakwet), all districts in the North-Eastern Province (Garissa, Mandera and Wajir) and three districts from Eastern Province (Isiolo, Kitui and Marsabit) has the second highest early childhood mortality, with a range from 121-165; while the third zone made up of one district in Nyanza (Kisii), six districts in the Rift Valley Province (Narok, Nakuru, Kericho, Uasin-Gishu, Nandi and Tranz-Nzoia), one in Eastern Province (Machakos), two from the Coast (Mombasa and Taita-Taveta) and Nairobi provincial-district, has an intermediate level of early childhood

TABLE 4.1 CLASSIFICATION OF KENYAN DISTRICTS BY SIZE OF CHILD MORTALITY BEFORE AGE 2 YEARS - 1000.q(2)

Province	DISTRICTS WITH GIVEN RANGE OF DEATHS PER 1000 BIRTHS				
	45-60	61-90	91-120	121-165	166-220
NYANZA			Kisii		Kisumu Siaya S. Nyanza
WESTERN				Kakamega Bungoma	Busia
RIFT-VALLEY		Laikipia Kajiado Samburu	Narok Nakuru Kericho Uasin-Gishu Nandi Trans-Nzoia	Turkana Elgeyo-Marakwet	Baringo W. Pokot
CENTRAL	Nyeri	Kiambu Muranga Kirinyaga Nyandarua			
NAIROBI			Nairobi		
NORTH-EASTERN				Garissa Wajir Mandera	
EASTERN		Embu Meru	Machakos	Isiolo Kitui Marsabit	
COAST			Mombasa Taita-Taveta		Kilifi Kwale Lamu Tana River

Source: Computer Printout

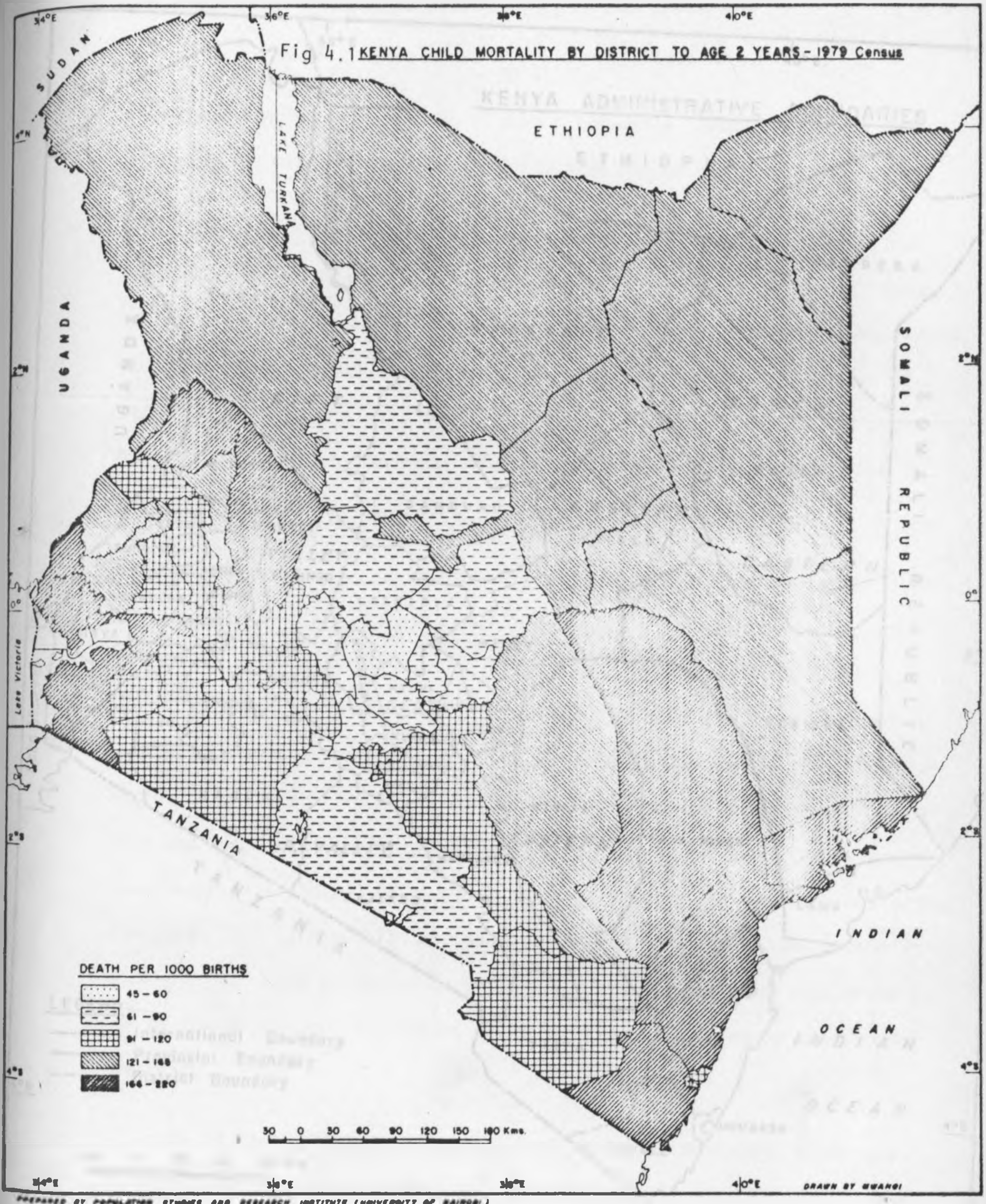
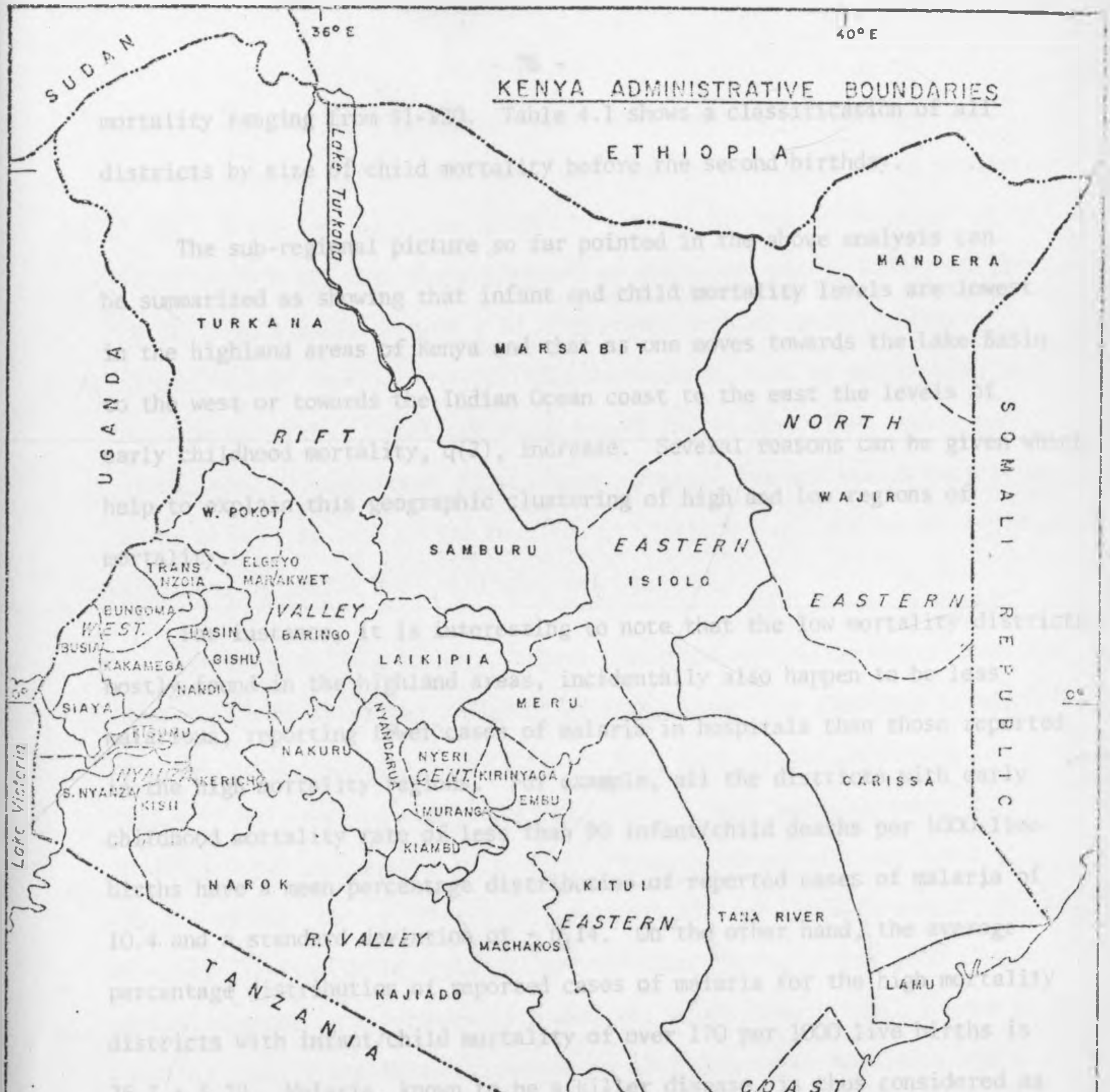


Fig 4.1 KENYA CHILD MORTALITY BY DISTRICT TO AGE 2 YEARS - 1979 Census
SUDAN
ETHIOPIA
LAKE TURKANA
UGANDA
SOMALI REPUBLIC
Lake Victoria
TANZANIA
INDIAN
OCEAN
DEATH PER 1000 BIRTHS
45 - 60
61 - 90
91 - 120
121 - 165
166 - 220
30 0 30 60 90 120 150 180 Kms.
34°E
36°E
38°E
40°E
4°N
2°N
0°
2°S
4°S
DRAWN BY MWANGI
PREPARED BY POPULATION STUDIES AND RESEARCH INSTITUTE (UNIVERSITY OF NAIROBI)


KENYA ADMINISTRATIVE BOUNDARIES
SUDAN
ETHIOPIA
UGANDA
SOMALI REPUBLIC
TANZANIA
Lake Turkana
Lake Victoria
36° E
40° E
0°
4°S
TURKANA
MARSABIT
MANDERA
NORTH
RIFT
WAJIR
W. POKOT
SAMBURU
EASTERN
ISIOLO
TRANS NZOIA
ELGEYO MARAKWET
VALLEY
EASTERN
BUNGOMA
WEST.
BUSIA
UASIN GISHU
BARINGO
KAKAMEGA
LAIKIPIA
NANDI
SIAYA
MERU
KISUMU
NAKURU
NYANDARUA
NYERI
CENT.
KIRINYAGA
EMBU
NYANZA
KERICHO
S. NYANZA
KISII
MURANGA
GARISSA
KIAMBU
NAROK
KITUI
EASTERN
TANA RIVER
R. VALLEY
MACHAKOS
KAJIADO
LAMU
COAST
INDIAN
OCEAN
KILIFI
TAITA
MOMBASA
KWALE
LEGEND
International Boundary
Provincial Boundary
District Boundary
40 0 40 80 120 KM.
M.S.H.

mortality ranging from 91-120. Table 4.1 shows a classification of all districts by size of child mortality before the second birthday.

The sub-regional picture so far pointed in the above analysis can be summarized as showing that infant and child mortality levels are lowest in the highland areas of Kenya and that as one moves towards the Lake Basin to the west or towards the Indian Ocean coast to the east the levels of early childhood mortality, q(2), increase. Several reasons can be given which help to explain this geographic clustering of high and low regions of mortality.

For instance, it is interesting to note that the low mortality districts mostly found in the highland areas, incidentally also happen to be less malarious, reporting fewer cases of malaria in hospitals than those reported in the high mortality regions. For example, all the districts with early childhood mortality rate of less than 90 infant/child deaths per 1000 live births have a mean percentage distribution of reported cases of malaria of 10.4 and a standard deviation of $\pm$ 6.14. On the other hand, the average percentage distribution of reported cases of malaria for the high mortality districts with infant/child mortality of over 170 per 1000 live births is 26.2 $\pm$ 5.79. Malaria, known to be a killer disease, is thus considered as one of the major contributors of regional variations in early childhood mortality.

It is also interesting to note that these low mortality districts (Kiambu, Muranga, Nyeri, Kirinyaga, Nyandarua, Laikipia, Kajiado, Samburu, Embu and Meru), incidentally tend to have higher mean percentage of women literate (32.33 $\pm$ 11.55), higher mean per capita high-potential agricultural land (0.662 + 0.53), higher mean number of kilometres of roads per 1000 square kilometres (118.7 + 72.93), lower mean percentage of urban population (7.982 + 4.21) and lower mean number of persons per health facility (15,770 + 7076.16) than the corresponding values of (15.9 + 9.34), (0.523 + 0.21), (98 + 64.56), (9.38 + 10.21) and (17370+11352.87) for the high mortality districts (Kisumu, Siaya, South Nyanza, Busia Kilifi, Kwale, Lamu, Tana River, Baringo and West Pokot). This is what one would expect in reality. Thus female education, road communication, agriculture, urbanization and health facilities can be said to be some of the contributory factors that lead to the regional variations in infant and child mortality.

It is surprising to note, however, that in the low mortality districts (districts with less than 90 infant or child deaths per 1000 live births), the mean total fertility rate (8.64 + 0.80), mean population density, (116 + 97.65), and the mean number of hospital beds per 1000 persons (0.879 + 0.40) as compared to the corresponding values of (7.92 + 0.41), (86.7 + 84.00), and (1.397 + 1.48), respectively for the high mortality districts (infant/Child mortality greater than 170 deaths per 1000 live births) are not in accordance with what one would expect. With regard to hospital beds, a possible explanation is that government hospitals are concentrated in the high mortality districts. An explanation for the behaviour of total fertility rate and population density is not clear at this stage. However, the expected relationship between mortality and these variables has been proved in the subsequent section on multivariate analysis.

Another point is that some of the districts with low mortality are geographically small in comparison with those with high mortality. For example, the mean area in square kilometres for the low mortality districts (infant/child mortality less than 90 per 1000) is 7265.3 ± 6333.8 as compared to 7506.6 ± 4638.0 for the high mortality districts (infant/child mortality greater than 170 per 1000). It may be argued that the smallness of the district enhances the administrative effectiveness and control of health which are obviously related to the decline of infant and child mortality in these small districts.

This is a very general picture, however, as this is relatively so for some areas except in the Rift Valley with smaller districts like Baringo and West Pokot slightly worse-off than the rest of the districts in that province. Again this is not so when districts in Central Province are compared with the districts in Nyanza and Western Provinces.

In relation to the other districts, Nairobi and Mombasa occupy a middle position with early childhood mortality of 93 and 120 deaths per 1000 live births slightly less than the average for the whole country (125 per 1000). The reason is not very clear. It is possible, however, that most of the urban dwellers live in the squalor where the standard of living is low, health conditions poor and infant and child welfare neglected. This seems to be the case in places such as Mathare Valley, some parts of Kawangware and many other slum areas. This weighs down the otherwise expected average for the city's infant and child population.

It must be mentioned, however, that in many cases these estimates must be treated with caution. In Table 4.1 it is apparent that in some districts the numbers of dead children had been under-reported. The most suspect areas are those in the Rift Valley Province where implausibly low mortality rates were reported for several districts.

Despite these reservations about the quality of the data, the broad patterns of geographical variations in infant and child mortality are apparent. Mortality among the young is low in Central Province and highest in areas in Nyanza and Coast Provinces. In fact, all the available estimates of early childhood mortality considered, show that the most disadvantaged district in Kenya is South Nyanza with an alarmingly high infant/child mortality (216 per 1000). Nyeri district with an infant/child mortality rate of 49 per 1000 live births appears to be better-off than the whole country.

4.3 Multivariate Analysis

The inter-district differential in mortality discussed so far in the analysis tends to have a greater depth of meaning when related to the existing levels, patterns and degrees of socio-economic development, health status and disease prevalence in the various districts. Within the districts, variations in the level and degree of development tend to influence infant and child mortality. Thus the effective control of mortality and morbidity among infants and young children is obviously a function of the levels of nutrition, the distribution of the available medical facilities, and the manner of using such and other resources. For example, access to health and medical facilities at the individual level largely depends on the availability of health services, knowledge of the role of such services and on the individual income. Thus, infant mortality has long been known to be directly responsive to fluctuations in community as well as personal well-being.

In order to investigate the implied direct/or indirect effect of mortality determinants on the levels of infant and child mortality, a number of indicators of socio-economic, health, disease and demographic conditions in Kenya for the nearest available dates were assembled from the sources indicated in Chapter II for the 41 administrative districts. These measures were chosen for dates nearest to the years 1976-77 taken to be the reference period for q(2) estimates. The selection was done bearing in mind the problems attendant on making cross-sectional analysis, and comparisons. A detailed discussion on data sources and measures is given in Chapter II.

The multivariate linear regression technique described in Chapter III has been applied to study such relationships. In this analysis the dependent variable is assumed to be linearly related to the explanatory variables and a linear regression model is considered appropriate since the magnitude of one variable is to be predicted from the knowledge of more than one explanatory variables. As was mentioned in Chapter III, this technique is applied to achieve the following objectives:

(i) To determine the extent to which the set of explanatory variables is capable of predicting the dependent variable;

(ii) To determine the absolute and relative degree of association between each of the independent variables and the dependent variable.

Multiple regression has, therefore, been employed in this analysis for the purposes of prediction, estimation and smoothing of the data. The multiple correlation coefficient provides a measure of significance of the regression. The coefficient of multiple determination (R^2) defined as the ratio of the variation explained by the knowledge of the independent variables to the total variation present in the dependent variable and its positive square root (R) called the coefficient of multiple correlation are used to test the significance of the regression model. The data for the 41 districts have been utilized and all districts were given equal weight in this study. However, the inclusion of Nairobi and Mombasa data may not be justified because some of their measures are either excessively higher or lower than for the rest of the districts. Measures such as percent urban population and percent women literate are higher and total fertility rate lower than for the rest of the districts. This limitation may not, however, cause major errors. Appendix C shows all these measures and their data for all districts.

Three kinds of analysis were carried out in this study. These were:

1. Intercorrelation analysis;
2. Partial correlation analysis;
3. Multiple regression analysis.

The results for these three types of analyses are outlined in the following sections.

4.3.1 Intercorrelation Analysis

The correlation coefficients based on the frequencies in Appendix C are reported in this section. Thus the first step to determining the separate covariances between mortality and each index of socio-economic development, health, disease and demographic factors is shown in Tables 4.2, 4.3 and 4.4 in the forms of matrices of zero-order, first order, second-order to sixth-order partial correlation coefficients.

TABLE 4.2 MATRIX OF ZERO-ORDER COEFFICIENTS OF CORRELATION (r)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1.000									
X_2	-0.076	1.000								
X_3	0.002	0.702	1.000							
X_4	-0.044	0.608	0.336	1.000						
X_5	-0.221	-0.564	-0.615	-0.301	1.000					
X_6	0.313	0.550	0.511	0.343	-0.380	1.000				
X_7	-0.461	0.450	0.404	-0.118	0.201	0.232	1.000			
X_8	0.082	0.581	0.103	0.314	-0.276	0.382	-0.001	1.000		
X_9	-0.154	0.607	0.616	0.222	-0.200	0.744	0.720	0.324	1.000	
X_{10}	-0.118	0.842	0.798	0.406	-0.368	0.465	0.609	0.294	0.698	1.000

Source: Computer Printout

A. Independent Variables

X_2 = Percent urban population
X_3 = Population per health facility
X_4 = Per capita high-potential agricultural land
X_5 = Total fertility rate
X_6 = Percent malaria cases
X_7 = Percent female adult literate
X_8 = Hospital beds per 1000 persons
X_9 = Kilometres of roads per 1000 square kilometres
X_{10} = Population density

B. Dependent Variable (X_1) = Probability of dying before age two.

TABLE 4.3 ZERO-ORDER COEFFICIENTS OF CORRELATION (r), DETERMINATION (r^2) AND CORRESPONDING "t" VALUES

Independent Variables	r	r^2	"t" value	P <
X_2 = Percent urban population	-0.076	0.006	0.478	.70
X_3 = Population per health facility	0.002	0.000	0.013	-
X_4 = Per capita high-potential agricultural land	-0.044	0.002	0.278	.80
X_5 = Total fertility rate	-0.221	0.049	1.412	.25
X_6 = Percent of malaria cases	0.313	0.098	2.060	.05
X_7 = Percent female adults literate	-0.461	0.212	3.240	.01
X_8 = Hospital beds per 1000 persons	0.082	0.007	0.518	.70
X_9 = Kilometres of roads	-0.154	0.024	0.973	.40
X_{10} = Population density	-0.118	0.014	0.742	.50

Source: Computer Printout

The first column of the table showing the zero-order correlation coefficients (Table 4.2) contains the individual coefficients between the probability of infant/or child dying before age 2 years (X_1) and each of the explanatory variables (X_2, ..., X_{10}).

The significance of the zero-order correlation coefficients can be appreciated fully by looking at the summary measures in Table 4.3. The t-test defined as $t(n-2)df = \frac{r \sqrt{n-2}}{\sqrt{(1-r^2)}}$ where r is the zero-order correlation coefficient and n is the sample size, shows that the zero-order correlation coefficients between X_1 and X_5, X_6 and X_7 are statistically significant at the p<0.25.

The malaria prevalence as measured by the percentage of reported cases over all new cases X_6, and the women's education measured by the percentage of women who have completed five or more school standards X_7, are the most important characteristics associated with infant/child mortality.

The third variable X_3, population per health facility is highly correlated with urbanization X_2 and, therefore, its effect on infant/child mortality is not clear because these two independent variables have not been isolated from each other. Therefore, their relevance to the mortality level cannot be postulated at this stage. The same applies to these variables: X_4 and X_2, the per capita high-potential agricultural land and percent urban population; X_9 and X_6, the number of kilometres of roads per 1000 square kilometres and percent reported cases of malaria, respectively; X_{10} and X_2, population density and urbanization; X_{10} and X_9, population density and kilometres of roads and X_{10} and X_7, population density and women literate which are also highly correlated.

4.3.2. Partial Correlation Analysis

The influence of independent variables on infant and child mortality has been inspected and assessed in the present study by using two approaches. One has been to examine the joint effect of X_2 to X_{10} on X_1; the other to observe their impact on X_1 separately by isolating the variables X_2 to X_{10}, holding constant as wide a range of intervening conditions as possible. Multiple regression formulated in Chapter III, involves both approaches. More specifically the technique of partial correlation uses the second approach in which some or all variables are held constant. Other techniques of partial and multiple correlation analysis include Blalock's causal analysis and Duncan's path analysis (Blalock, H.M., 1979).

The most important finding in the results shown in Table 4.4 is the strong interdependence between infant/child mortality X_1 and women's education as measured by the percent female adults with five or more years of schooling, X_7. The impact of education of women on infant and child mortality is substantial. Partial correlation between X_1 and women's education, X_7 increases each time an additional variable is held constant. The partials increase from $r_{17.6} = -0.4605$ to $r_{17.624...3} = -0.6680$ then declines slightly to $r_{17.6...9} = -0.6618$ when hospital beds X_9 enters into the sixth-order correlation coefficient. Thus the fifth-order correlation coefficient gives support to the hypothesis of maternal education as the most important socio-economic condition favouring low infant and child mortality levels. Therefore, the chances of infant and child mortality decrease with increasing levels of education among women. High proportions of women with five or more school years in the educationally advanced districts (such as Nyeri and Kiambu in Central Province) is in accord with the general lower levels of infant and child mortality in these districts. The results of the present study, therefore, accord with the general belief that maternal education influences the amount of care given to infants/or young children.

Another most important finding in the results shown in Table 4.4 is the strong interdependence between mortality X_1 and malaria X_6 as measured by the percent reported cases. A similar finding was obtained in the analysis of 1969 Census data by Anker and Knowles who observed that malaria and life expectancy at birth had a highly significant relationship at the 1 percent level (Anker R. and Knowles, J.C., 1977, pp. 15-16).

As compared with the zero-order correlation $r_{16} = 0.3133$ the partial correlation rises successively from the first-order partial $r_{16.7} = 0.4863$ to the fifth-order partial $r_{16.7...5} = 0.5897$ when the variables X_6, X_2, X_4, X_{10}, and X_5 are entered in that order.

Malaria has long been known to be a direct cause of death and, therefore, its rise or decline within the districts will reflect the levels of infant and child mortality. Thus, a consequence of malaria control may result in lower levels of infant and child mortality.

The effect of urbanization X_2, as measurd by the percent urban population, is less substantial but nevertheless spectacular. The partials between mortality X_1 and urbanization X_2 decrease from $r_{12} = -0.0763$ in the zero-order to $r_{12,76103} = -0.3853$ in the fourth-order. The coefficient then increases to $r_{12.761038} = -0.3682$ and then declines eventually to $r_{12.76...9} = -0.4191$ when kilometres of roads, X_9 enters in the sixth-order partial correlation. Thus the fourth-order correlation gives support to the priori hypothesis that urbanization favours low early childhood mortality. Anker and Knowles (1977) observed in their analysis of mortality differentials that the first-order correlation between urbanization and life expectancy at birth was positive (r = 0.15), consistent with their priori hypothesis. They excluded Mombasa and Nairobi in their regression analysis. After adjusting for the higher educational levels and the more extensive medical facilities found in the urban areas, they observed that urbanization in Kenya does not provide a healthier environment than that provided by the rural areas (Anker, R. and Knowles, J.C., 1977, p. 16).

The present findings, with Nairobi and Mombasa included, are not in agreement with what Anker and Knowles (1977) observed in their study based on the 1969 Census and other micro and macro-level data on the socio-economic, health, disease and demographic conditions. It is clear from the drop of the partial at the fifth-order when health facilities X_8 is controlled for that urbanization has a negative effect on infant and child mortality after controlling for women's education X_7 and health facilities X_8 which are higher in the urban areas. It seems, therefore, that the situation has changed over the recent years. It can be seen directly by comparing the levels of mortality in Appendix C. Obviously, infant/child mortality for Nairobi is only slightly higher than that for a few districts such as Nyeri, Kiambu, Muranga, Nyandarua, Kirinyaga, Laikipia, Kajiado, Samburu, Kericho, Uasin-Gishu, Embu and Meru districts. The observed effect of urban centres on the chances of an infant or child surviving may be due to the greater number of medical facilities, greater access to these facilities and also higher educational levels.

Another variable of importance is population density as measured by the number of persons per square kilometre, X_{10}. Though not very substantial, the partials lend support to the priori expectations that population density is positively related to infant and child mortality. Partial correlation between child mortality index X_1, and population density, X_{10} increases each time an additional variable is controlled for. The partials increase from r_{110} = -0.1179 at the zero-order to $r_{110.76...9}$ = 0.4097 at the sixth-order. Thus the sixth-order partial correlation coefficient strongly support the a priori hypothesis.

TABLE 4.4 PARTIAL CORRELATION MEASURES OF ASSOCIATION BETWEEN CHILD MORTALITY AND EACH DETERMINANT

Description of Correlated Measures	Partial Correlation $r_{ij.k\ldots n}$	Variables Held Constant
Mortality index X_1, and women's education, X_7	$r_{17} = -0.04605$	None
	$r_{17.6} = -0.5770$	X_6
	$r_{17.62} = -0.5377$	X_6, X_2
	$r_{17.624} = -0.6023$	X_6, X_2, X_4
	$r_{17.62410} = -0.6651$	X_6, X_2, X_4, X_{10}
	$r_{17.624103} = -0.6680$	X_6, X_2, X_4, X_{10}, X_3
	$r_{17.6241039} = -0.6618$	X_6, X_2, X_4, X_{10}, X_3, X_9
Mortality index X_1, and Malaria Prevalence, X_6	$r_{16} = 0.3133$	None
	$r_{16.7} = 0.4863$	X_7
	$r_{16.72} = 0.5084$	X_7, X_2
	$r_{16.724} = 0.5369$	X_7, X_2, X_4
	$r_{16.72410} = 0.5897$	X_7, X_2, X_4, X_{10}
	$r_{16.724105} = 0.5897$	X_7, X_2, X_4, X_{10}, X_5
	$r_{16.7241058} = 0.5851$	X_7, X_2, X_4, X_{10}, X_5, X_8
Mortality index X_1, and Fertility, X_5	$r_{15} = -0.2205$	None
	$r_{15.7} = -0.1472$	X_7
	$r_{15.76} = 0.0902$	X_7, X_6
	$r_{15.764} = 0.0430$	X_7, X_6, X_4
	$r_{15.76410} = 0.2630$	X_7, X_6, X_4, X_{10}
	$r_{15.764108} = 0.2636$	X_7, X_6, X_4, X_{10}, X_8
	$r_{15.7641089} = 0.2228$	X_7, X_6, X_4, X_{10}, X_8, X_9
Mortality index X_1, and agriculture, X_4	$r_{14} = -0.0444$	None
	$r_{14.7} = -0.1117$	X_7
	$r_{14.76} = -0.3692$	X_7, X_6
	$r_{14.762} = -0.3220$	X_7, X_6, X_2
	$r_{14.76210} = -0.3573$	X_7, X_6, X_2, X_{10}
	$r_{14.762105} = -0.3930$	X_7, X_6, X_2, X_{10}, X_5
	$r_{14.7621058} = -0.3785$	X_7, X_6, X_2, X_{10}, X_5, X_8

Description of Correlated Measures	Partial Correlation $r_{ij.k\ldots n}$	Variables Held Constant
Mortality index X_1, and health facilities, X_3	r_{13} = 0.0021	None
	$r_{13.7}$ = 0.2316	X_7
	$r_{13.76}$ = 0.0044	X_7, X_6
	$r_{13.762}$ = 0.1466	X_7, X_6, X_2
	$r_{13.76210}$ = -0.0533	X_7, X_6, X_2, X_{10}
	$r_{13.762105}$ = -0.0626	$X_7, X_6, X_2, X_{10}, X_5$
	$r_{13.7621059}$ = -0.0560	$X_7, X_6, X_2, X_{10}, X_5, X_9$
Mortality index X_1, and urbanization, X_2	r_{12} = -0.0763	None
	$r_{12.7}$ = -0.1024	X_7
	$r_{12.76}$ = -0.1972	X_7, X_6
	$r_{12.7610}$ = -0.3830	X_7, X_6, X_{10}
	$r_{12.76103}$ = -0.3853	X_7, X_6, X_{10}, X_3
	$r_{12.761038}$ = -0.3682	$X_7, X_6, X_{10}, X_3, X_8$
	$r_{12.7610389}$ = -0.4191	$X_7, X_6, X_{10}, X_3, X_8, X_9$
Mortality X_1, and Hospital beds, X_8	r_{18} = 0.0818	None
	$r_{18.7}$ = 0.0916	X_7,
	$r_{18.76}$ = -0.1238	X_7, X_6
	$r_{18.7610}$ = -0.1365	X_7, X_6, X_{10}
	$r_{18.76103}$ = -0.1588	X_7, X_6, X_{10}, X_3
	$r_{18.761035}$ = -0.1277	$X_7, X_6, X_{10}, X_3, X_5$
	$r_{18.7610359}$ = -0.0527	$X_7, X_6, X_{10}, X_3, X_5, X_9$
Mortality X_1 and Kilometres of roads, X_9	r_{19} = -0.1541	None
	$r_{19.7}$ = -0.2817	X_7
	$r_{19.76}$ = -0.2834	X_7, X_6
	$r_{19.7610}$ = -0.3001	X_7, X_6, X_{10}
	$r_{19.76103}$ = -0.2990	X_7, X_6, X_{10}, X_3
	$r_{19.761035}$ = -0.2861	$X_7, X_6, X_{10}, X_3, X_5$
	$r_{19.7610359}$ = -0.2632	$X_7, X_6, X_{10}, X_3, X_5, X_9$

Description of Correlated Measures	Partial Correlation $r_{ij.k\ ...n}$	Variables Held Constant
Mortality X_1, and Popualtion density, X_{10}	r_{110} = -0.1179	None
	$r_{110.7}$ = 0.2311	X_7
	$r_{110.76}$ = 0.0338	X_7, X_6
	$r_{110.762}$ = 0.3364	X_7, X_6, X_2
	$r_{110.7624}$ = 0.3700	X_7, X_6, X_2, X_4
	$r_{110.76245}$ = 0.3928	X_7, X_6, X_2, X_4, X_5
	$r_{110.762459}$ = 0.4097	X_7, X_6, X_2, X_4, X_5, X_9

Source: Computer Printout

The kilometres of roads, X_9 is also another important variable. Though the partials shown in Table 4.5 are not very substantial, they lend support to the priori expectations that the number of kilometres of roads is negatively related to mortality. Partial correlation between child mortality index X_1, and kilometres of roads, X_9, decreases each time an additional variable is held constant except for variables, X_3, X_5 and X_9. The partials decrease from r_{19} = -0.1541 to r_{19} = -0.3001 in the third-order. When X_3, X_5 and X_9 enter into the sixth-order, the partial increases to $r_{19.7\ ...59}$ = -0.2632.

Thus the third-order correlation gives strong support to the priori hypothesis that roads are negatively related to the levels of infant and child mortality. This is an important variable which has always been neglected by researchers on differential mortality analysis.

Agriculture X_4, as measured by the per capita high-potential land was also found to be negatively related to infant and child mortality X_1.

For example, if variable X_4, is permitted to vary with X_1, all the partial correlation coefficients are consistent with the priori hypothesis (see Table 4.4). The partial correlation coefficients between X_1 and X_4 decrease each time the effect of an additional variable is controlled for, except for hospital beds, X_8. The partials decrease from the negative coefficient $r_{14} = -0.0444$ of the zero-order to $r_{14.7...5} = -0.3930$ at the fifth-order then rises to the sixth-order partial $r_{14.7...8} = -0.3785$ when hospital beds X_8 is introduced. Clearly, the fifth-order partial correlation coefficient strongly supports the hypothesis of agricultural land as a socio-economic condition favouring low infant and child mortality levels.

Plenty of food and less malnutrition in most parts of the countryside is in accord with the general lower levels of mortality among infants and young children in the rural areas.

Some of the results in Table 4.4 were not anticipated. For example, if variable X_5, total fertility rate is permitted to vary with X_1, both the zero-order and the first-order partial correlation coefficients cast doubt on the presumption that fertility per se, as measured by total fertility rate (TFR), is relevant to infant/child mortality. The inverse relationship exhibited by TFR, X_5 with mortality levels X_1 is inconsistent with a priori expectations. However, when all else is controlled for there is evidence for the child survival hypothesis. It is observed in Table 4.4, for example, that the negative coefficient reverses sign at the second-order so that $r_{15.76} = 0.0902$. A further increase occurs up to the the fifth-order partial $r_{15.76...8} = 0.2636$. The fifth-order partial correlation lends strong support to the hypothesised relationship. The multiple regression results in the next section also indicate that total fertility rate (TFR) exhibits the hypothesised relationship with infant/child mortality. Judging alone on the basis of partial correlation coefficients, it is impossible, at this stage, to make a categorical assertion about the existing relationship between reproduction (TFR) and the incidence of infant/or child mortality, X_1. Furthermore, considering the variables, X_1 and X_5 in isolation, neither is mortality per se the cause of high fertility, nor is high fertility likely to be the cause of low mortality. Currently, much discussion in popular literature centres around the topic of infant mortality as the prime agent responsible for the rise in fertility levels (CICRED, 1975; W.H.O., 1980a).

Some evidence has been accumulated which suggests that fertility can have a substantial effect on infant mortality. More specifically, several studies have demonstrated that infants born after a relatively short interval experience considerably higher mortality than those born after long intervals (R.W. Woodbury, 1925, pp. 60-67). The reasons underlying this relationship are somewhat unclear. Several factors can be suggested which might affect adversely the chances of life of infants who follow the preceding birth closely. Two or more births in rapid succession might weaken the mother and a physically weak mother is perhaps less capable of giving adequate care to a child during the critical period of infancy. It is also possible that the presence of a second child in the household at the time of a birth would reduce the amount of care and attention the mother could afford to give to the newborn infants. Knodel's findings in his study of Bavarian villages supports the hypothesis that a second infant or young child in the household consumes some of the care that the mother would otherwise be devoting to the newborn infant (Knodel, J., 1968). Thus children in larger families may receive less care than those in small families and hence experience higher mortality.

The relationship between infant/child mortality X_1 and hospital beds X_8 (measured by the number of beds per 1000 persons) as suggested by the zero-order and the first-order partial correlation coefficients was not anticipated. However, this relationship is reversed in the second-order when malaria, X_6 is included. A negative relationship is then maintained by controlling successively the effect of up to six explanatory variables. It is clear from Table 4.4 that the fourth-order partial $r_{18.76105} = -0.1588$ supports the a priori hypothesis.

Another result which was not expected is the relationship exhibited by X_3 with X_1. For instance, if we permit variable X_3, population per health facility, to vary with mortality X_1, a complete reversal from a direct to an inverse relationship occurs by holding constant successively up to three extraneous explanatory variables. Clearly the positive coefficient of the first-order $r_{13.7} = 0.2316$ becomes the negative coefficient of the fourth-order, $r_{13.76210} = -0.0533$. Clearly the positive coefficient of the zero-order $r_{13} = 0.0021$ rises to $r_{13.7} = 0.2316$ when education of women X_7, is held constant, indicating that less facilities are found where women are more educated. The negative relationship suggested by the partials in the fourth-order, fifth-order and sixth-order were not anticipated. This does not mean, however, that health facilities are not crucial as indices of health status of the districts. Indeed, health facilities is an important variable. In fact the first-order partial, $r_{13.7}$, which lends support to the a priori hypothesis, has greater magnitude than the other partials. The most likely problem with the level of the partial correlation coefficients is that the variable presently ill-defines the status of health. The multiple regression results indicate, however, that health facilities, X_3, exhibits the hypothesized relationship with infant/child mortality.

It has already been shown in the discussion of the zero-order correlation coefficients that some reasonable degree of intercorrelation existed among the variables. An attempt has also been made to study the separate as well as the combined covariance of the set of variables under study. The following section presents the regression results.

4.3.3. Regression Analysis

As already stated in Chapter III, the linear model used is of the form

$$X_1 = a_o + b_1X_2 + b_2X_3 + \dots + b_{10}X_{10} + e$$

where X_1, X_2 ..., X_{10} are as defined in the preceding discussion.

By fitting this additive model to the data by Ordinary Least Square Method (OLS), the following relationship was obtained:

$$X_1 = 98.465 - 0.9095X_2 + 0.0001X_3 - 4.8308X_4 + 4.3573X_5 + 2.7055X_6 - 1.9485X_7 + 3.8569X_8 - 0.1620X_9 + 0.1085X_{10}$$

where X's are the actual values of the variables and are not measured from their respective means. The constants attached with the variables in the above equation are called the regression coefficients. They indicate the association with infant/child mortality rate (measured by 1000 q(2)) for a change in the accompanying independent variable, when allowance has been made for the other independent variables.

Thus b_1 = 0.9095 is an estimate of the variation in infant/child mortality rate X_1 associated with a variation in percentage urban population X_2 independent of the variation in the other eight independent variables, i.e. X_3, X_4, X_5, X_6, X_7, X_8, X_9 and X_{10}. The other regression coefficients can be interpreted in a similar way. However, in interpreting these regression coefficients one should bear in mind the different orders of magnitude for the variables. This is made clear at the conclusion section of this chapter.

The first term in the left hand side of the equation is the hypothetical value of infant/child mortality, when the other variables have a value of zero. The estimate of infant/child mortality rate for any district is the sum of the net amounts associated with each independent variable plus the value (98.465). These estimated values of infant/child mortality rate along with their original values and their differences are set out in Table 4.5.

By applying X^2 test defined as $X^2 = \frac{\sum(O-E)^2}{E}$ where O and E are the observed and expected frequency, respectively, the fitted model was tested for goodness of fit and it was found to be a reasonably good fit. The calculated value of X^2 was 25.34.

If all the factors are taken together, the multiple correlation for the nine independent variables amounts to R = 0.771. The corresponding

TABLE 4.5 ACTUAL (OBSERVED) AND ESTIMATED (EXPECTED) VALUES OF INFANT/CHILD MORTALITY RATES IN KENYAN DISTRICTS - 1979

District	Observed (1000.q(2)) (O)	Expected (1000.q(2)) (E)	O-E
1. Nyeri	49	43.03	5.97
2. Nyandarua	64	50.76	13.24
3. Muranga	68	87.94	-19.94
4. Kiambu	70	42.21	27.79
5. Kajiado	75	87.49	-12.49
6. Meru	75	114.15	-39.15
7. Laikipia	77	70.77	6.23
8. Samburu	77	135.69	-58.69
9. Kirinyaga	82	106.21	-24.10
10. Embu	83	105.99	-22.99
11. Kericho	91	113.96	-22.96
12. Uasin Gishu	92	94.93	- 2.93
13. Nairobi	93	47.74	45.26
14. Narok	95	73.68	21.32
15. Nakuru	97	91.53	5.47
16. Machakos	98	112.10	-14.10
17. Kisii	101	137.59	-36.59
18. Nandi	110	110.38	- 0.38
19. Trans Nzoia	114	111.64	2.36
20. Taita Taveta	116	153.26	-37.26
21. Mombasa	120	146.87	-26.87
22. Elgeyo Marakwet	127	113.69	13.31
23. Isiolo	127	168.90	-41.9
24. Wajir	129	173.50	-44.5
25. Marsabit	130	164.62	-34.62
26. Garissa	131	186.09	-55.09
27. Turkana	133	144.50	-11.50
28. Bungoma	140	139.07	0.93
29. Kakamega	143	158.55	-15.55
30. Mandera	146	172.67	-26.67
31. Kitui	148	163.28	-15.28
32. Baringo	171	128.58	42.42
33. Tana River	181	194.64	-17.64
34. West Pokot	188	177.33	10.64
35. Kwale	190	169.35	20.65
36. Busia	198	149.00	49.00
37. Kisumu	199	136.04	62.96
38. Lamu	200	168.25	31.75
39. Siaya	211	166.99	44.01
40. Kilifi	212	173.89	38.11
41. South Nyanza	216	162.25	53.75

Source: Computer Printout

value of the coefficient of determination (R^2) is 0.594. It is therefore concluded that by the use of the nine independent variables, we have explained 59.4 percent of the variation in the dependent variable, X_1 (early childhood mortality rate - q(2)) - if no deliberate distortions exist. (Table 4.6).

The significance of the multiple correlation coefficient was tested by applying the F-test defined in Chapter III as

$F = R^2(n-p-1)/(1-R^2)p$ with (p, n-p-1) degrees of freedom where R is the multiple correlation coefficient, p is the number of independent variables used and n is the number of cases. It was found that four of the coefficients are significant at the $p<0.10$. That is testing the significance of the multiple correlation coefficient at the 95 percent confidence interval $R = 0.7444 \pm 1.96 \times .5541$ which gives a lower limit of the .95 confidence interval of R = 0.5874 and an upper limit of 0.9014 which is obviously significant. The standard error of the estimate is low if all the variables are taken into account in the regression model. The standard errors of the estimates with different combinations of independent variables are available in the computer printout.

Furthermore, the corresponding "F" test value of 5.039 shows that multiple coefficient of determination for the nine explanatory variables sufficiently exceeds zero.

Analysis of variance technique was also applied intesting the significance of the sum of squares due to regression and it was found to be significant. The analysis of variance for the multiple regression

TABLE 4.6 MULTIPLE AND REGRESSION COEFFICIENTS (β_j's) OF NINE DEMOGRAPHIC, SOCIO-ECONOMIC, DISEASE AND HEALTH VARIABLES WITH PROBABILITY OF DYING BEFORE AGE 2

Regression Variables	Regression Coefficients (β_j)	"t" Test	
		Values	P<, df = 39
X_2 = Percent urban population	-0.909	0.936	0.40
X_3 = Population per health facility	0.0001	0.193	0.90
X_4 = Per capita high-potential agricultural land	-4.831	1.740	0.10
X_5 = Total Fertility Rate	4.357	0.468	0.70
X_6 = Percent malaria cases	2.705	3.634	0.001
X_7 = Percent female adults literate	-1.948	1.888	0.10
X_8 = Hospital beds per 1000 persons	3.857	0.449	0.70
X_9 = Kilometres of roads	-0.162	1.441	0.20
X_{10} = Population density	0.108	2.090	0.05

Source: Computer Printout.

(a) Multiple Coefficient of Determination (R^2) = 0.594

(b) Multiple Correlation Coefficient (R) = 0.771

yielded the following summary results:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
(a) Due to regression	9	53724.76	5969.42	5.039
(b) Deviation about regression	31	36724.21	1184.65	-
	40	90448.97		

Source: Computer Printout.

4.3.4. Revised Regression Analysis

In order to examine more closely the behaviour of some of the explanatory variables and to minimize the effect of obvious intercorrelations among the explanatory variables, a revised regression analysis was made on a reduced number of variables. Out of the original nine, four, which judging from the partial correlation coefficients, were not significant or were considered to introduce intercorrelational problems were left out. Thus the following analysis is based on the four explanatory variables presented in Table 4.7. The results of this second analysis are placed side by side with those of the first test for comparative purposes.

It is clear from the results of the two tests that the estimates of the probability of dying before age 2, X_1 made by the use of all the independent variables in the regression model will be more efficient than those made by using fewer independent variables, although the inclusion of X_8 (hospital beds per 1000 persons) does not help much in explaining the variation present in the dependent variable.

However, one thing clear is that all the corresponding 't' values rose up in the second test. The levels of significance also changed from $P < .1$ to $P < .01$, $P < .1$ to $P < .001$.

TABLE 4.7 MULTIPLE AND PARTIAL COEFFICIENTS OF CORRELATION (β's) OF 4 SOCIO-ECONOMIC, DEMOGRAPHIC, DISEASE AND HEALTH VARIABLES WITH PROBABILITY OF DYING BEFORE AGE 2 YEARS

Regression Variables	FIRST TEST USING 9 VARIABLES			SECOND TEST USING 4 VARIABLES		
	Regression Coefficients (β's)	"t" Tests		Regression Coefficients (β's)	"t" Tests	
		Value	P<,df=39		Value	P<,df=39
X_4 = Per capita Agri-cultural land	-4.831	-1.740	0.1	-6.328	-3.085	0.01
X_6 = Percent Malaria Cases	2.705	3.634	0.001	1.594	3.810	0.001
X_7 = Percent Female Adults Literate	-1.948	-1.888	0.1	-2.536	-5.014	0.001
X_{10} = Population Density	0.108	1.831	0.1	0.053	1.831	0.100

Source: Computer Printout

Multiple Coefficient of Determination (R^2) = 0.525

Multiple Coefficient of Correlation (R) = 0.724

Although the partial β scores have decreased for some variables considered in the second run, each variable continues to support the priori hypotheses that disease prevalence, as measured by the percentage malaria cases, and population density correlate positively with infant/child mortality; that socio-economic variables (percent female adults literate and percent per capita high-potential agricultural land) correlate negatively with early childhood mortality. Thus increased levels of socio-economic development in the districts implies decreased levels of child mortality. In this respect, the major indices of socio-economic development are, once again, percent female adults literate and per capita high potential agricultural land in that order of importance.

It can also be seen that differences between the coefficients of determination based on nine variables ($R^2 = 0.594$) and on four variables ($R^2 = 0.525$) is not large. Thus, whereas the original nine variables collectively explained 59.4 percent of the variations in mortality, the four variables alone explained 52.5 percent of the variation, so that the removal of the other five variables led to a decrease of only 6.9 percent in the originally explained total variation. This clearly implies that the bulk of the explained variation in the first test using nine variables was actually due to the four variables retained in the second run.

The new multiple correlation coefficient ($R = 0.724$) still remains significant ($P < 001$) with the lower limit of the .95 confidence interval at $R = 0.5537$ and the upper limit at $R = 0.8804$. The new corresponding F-test value ($F = 9.937$) was greater than the original ($F = 5.039$).

To test the significance of the sums of squares due to the second regression the analysis of variance technique was also applied. The accompanying analysis of variance for the second multiple regression yielded the following summary results:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Value
(a) Due to regression	4	47462.84	11865.71	9.937
(b) Deviation about regression	34	42986.14	1194.06	-
Total	38	90448.98		

Source: Computer Printout

4.4 Conclusion

In this chapter it has been shown that the level of infant/child mortality in Kenya is very high (125/1000) and in the case of South Nyanza District alarmingly high (216/1000). Nyeri District has the lowest child mortality rate (49/1000), in the whole country. In general the mortality estimates examined here indicate that child mortality levels are lowest in the highland areas and highest in those areas nearest to the Lake Basin and the Indian Ocean coast.

The Linear Regression model has been very useful in finding out the inter-relationship among variables and for predictive purposes in this chapter. The association of infant/child mortality with per capita agricultural land, urbanization, female education, population density, hospital beds, health facilities, total fertility rate, kilometres of roads and malaria individually or in combination, was studied by fitting an additive regression model to the data of the 41 Kenyan districts. It is observed that the percentage of women who have completed five or more standards of education had the highest association with infant/child mortality rate. As the percent adult females with five or more school years increases, the level of child mortality decreases.

It is clear from the regression equation obtained (p.94) that if the percentage of women literate (with five or more school years) is raised by 50 percent, say from 30 percent to 60 percent, the impact is to reduce the level of mortality by 58 deaths per 1000. On the other hand, malaria eradication would have a bigger impact on mortality. The regression equation suggests that when the percent cases which are malaria is reduced, say from 30 to 0, this would have an effect of reducing child mortality level by about 81 deaths per 1000 births. As regards urbanization, the regression equation shows that when the percentage urban population is increased by about 30 percent in Kenya, the resulting quantitative effect is a reduction in mortality by approximately 18 deaths per 1000, when allowance is made for the other factors.

Although the regression constant attached to the fertility variable in the regression equation is high in comparison with those attached to the above variables, yet the range of variation on this variable is not as wide as that for the other variables. For example, total fertility rate can only vary from 1 to about 10 whereas the rates of female education, malaria and urbanization have a wider range. For instance, a unit change in total fertility rate would only effect a child mortality change of about 4 deaths per 1000 births only. Furthermore, to bring such a unit change in fertility would require more effort and more time because it involves changing the attitudes of the people towards birth control. Similarly, agriculture variable though attached to a bigger regression constant, has less quantitative effect on the mortality rate.

As regards health services, the regression equation suggests that if the population per health facility is reduced by 10,000 persons by providing more health facilities (health centres, health subcentres and dispensaries) to the people then child mortality rate would be reduced by only 1 death per 1000 births. This suggests clearly that health facilities are insignificant as concerns their impact on child mortality. The regression equation also suggests that hospital beds has a positive relationship with child mortality. This was not anticipated. Obviously, the problem here is the non-linearity of the variables. It is apparent that more health facilities are found in the high mortality regions.

The remaining variables, kilometres of roads per 1000 square kilometres and population density (number of persons per 1000 square kilometres) were also observed to have considerable quantitative effect on child mortality. As suggested by the regression equation, an addition of about 100 kilometres of roads per 1000 square kilometres would lower child mortality by about 16.2/1000 and an increase in population density by 100 persons would raise child mortality rate by about 11/1000.

About 52.5 percent of the variation present in child mortality index had been explained by only four variables (namely women's education, malaria, per capita agricultural land and population density) as compared with 59.4 percent explained by all the nine variables together. The standard error of the estimate of mortality is lowest, if these four variables are used (29.58) than that made by the use of all the variables (30.10). Therefore the estimates of the probability of dying before age 2 years, q(2) made by the use of all the variables will not be more satisfactory than those made by using fewer independent variables.

In this chapter it was not possible to obtain conclusive results as regards the importance of health facilities, hospital beds and total fertility rate as mortality predictors. It is concluded that health facilities ill-define the health status of the young children. They may not be effective as concerns their impact on infant and child mortality.

CHAPTER V

THE ROLE OF EDUCATION IN DETERMINING MORTALITY DIFFERENTIALS

CHAPTER 5

THE ROLE OF FEMALE EDUCATION IN DETERMINING MORTALITY DIFFERENTIALS

5.1 Introduction

In the previous chapter (Chapter IV), it was observed that the one factor which was of surprising importance in the explanation of child mortality levels among the districts was women's education. This chapter analyses the levels of child mortality in the Kenyan districts with special reference to the effects of the educational attainment of women. Maternal education has been considered rather than paternal because of three main reasons. First, it is an index of socioeconomic status. More important, however, it is to get an idea of how much effect educational programs have on child mortality. Another reason has been the lack of child mortality data by paternal educational levels.

Education is generally considered as a principal factor which is related to development as it affects mortality. This relationship is viewed as indirect since it works itself through health. Obviously, education of mothers affects post-neonatal mortality for infants and young children, because survival rates at early ages are largely affected by the social and educational conditions of the mothers, which determine their diet and the nature of their child care. For example, the mother's education may lead to the practice of boiling water which can reduce the incidence of diarrheal diseases and, therefore, reduce infant and child mortality. The fact that there is always a tendency for educated females to be married to educated males has its advantages of raising per capita income and promoting health awareness in the family.

In fact mass literacy which has resulted from the institution of free education and the teaching of personal hygiene in schools can be said to have created a far greater awareness of health matters among the population, encouraging the application of basic good health practices, and leading to earlier recognition and treatment of disease (U.N., 1973, p. 149). Thus woman's level of education has been considered rather than man's simply because it is generally believed that women are the ones solely responsible for infant and child-care and it is assumed that the more educated a woman is, the more aware she becomes of the factors that determine her child's health.

In this chapter it is shown that the educational attainment of women plays an important role in the reduction of child mortality levels. It is also shown that the inter-district differentials in child mortality cannot be ascribed exclusively to the inter-district educational variations. It is illustrated graphically that regional mortality differentials are not eliminated at all by increasing educational attainment of women.

A lot of evidence has been accumulated which suggests that a strong inverse association exists between the levels of infant and child mortality by educational attainment both at the micro and macro level. The results of this chapter suggest this to also be the case in Kenya.

5.2 Background on Mortality Differentials by Women's Education

Differential mortality by education of mothers has been noted among sub-populations in many regions of the world. A survey carried out in Greater Bombay in 1966, showed that the infant mortality rate among mothers with no education was almost double that among mothers who had completed elementary education and almost three times that among mothers with education beyond elementary levels (Ruzicka, L.T. and Kanitkar, T., 1972).

In a 1973 Indonesian Survey, it was reported that the proportion of a birth cohort dying before reaching their fifth birthday fell with increasing education of mother, from no education to some elementary education, to completed elementary education and above, in the rural areas of West Central and East Java, in Bali, Sulawesi (Celebes) and in the urban areas of all these regions except West Java where the mortality of children of mothers with incomplete elementary schooling was highest (Lembaga, D. 1973).

It is also interesting to note that very low infant and child mortality levels have been achieved in some societies where levels of female education are high, health inputs moderate and per capita income low to moderate. Kerala and Sri Lanka have been reported as prime examples of this situation. Caldwell (1979) observes that in the early 1970's income per head for India, Kerala and Sri Lanka was around $120; their literacy levels were 36 percent, 60 percent and 85 percent, respectively and female literacy levels were closer to male levels in Kerala and Sri Lanka. The reported infant mortality rates were around 130, 65 and 50, respectively, emphasizing the fact that female education plays a major role in determining mortality differentials.

The 1973 National Demographic Survey of the Philippines reported infant and child mortality rates that fell steeply by education of mother (Alcantara, A.N.,). Similarly, q(2), derived from proportions of children surviving for eight Latin American countries during the first half of the 1970's declined steeply with increasing education of mother (Behm, H., et. al., 1976-77). It was also shown that once maternal education was controlled, urban-rural differentials became trivial in Ecuador and Chile. Child mortality has been recorded as declining with maternal literacy in Costa Rica, Mexico and East Pakistan (now Bangladesh) - (Sloan, F., 1971, pp. 42-57).

In the United States, the infant mortality rate for mothers with no education or elementary education has been shown to be double that of mothers with college education, and the differential was greater than by father's education (Kitagawa and Hauser, 1973, pp. 28-29).

Kusukawa (1973) showed that female literacy played an important part in explaining variations in the expectation of life at birth. A. U.N. study of 115 countries showed higher correlation between literacy and life expectancy at birth than between any other specific factor considered and expectation of life (Granaham, D.V., et. al., 1974).

A great deal of evidence has accumulated that maternal education plays a major role in determining the level of infant and child mortality, but little attempt has been made to explain this important phenomena. It frequently seems to have been assumed that maternal education is merely a mortality differentials.

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Recent observations in Africa also show steep declines in child mortality with increasing educational attainment of mothers. In the Ghananian Census of 1960 it was reported that the proportion of children dead was almost twice as high for mothers with no education as for mothers with secondary education both in urban as well as in rural areas (Gaisie, S.K., 1969). Similar surveys carried out in Ghana (1965-66), Upper Volta (1969), and Niger (1970) showed that the ratios of the proportion of children dead to mothers with education ranged from 1.1 to 1.4 in urban areas and from 1.3 to 1.4 in rural areas (Pool, D.I., Harrington, J., Dandoussou, S. Diarra, D. Laya and Pool, D.I., respectively).

In a study of mortality differentials in a rural area of Nigeria, it was reported that the major socioeconomic factor which explained variations in mortality was mother's education (Orubuloye and Caldwell, J.C., 1975). The mechanism, however, was not clear and the problem was not explored further at that time. The study showed that the differential use of health facilities by mother's education was not statistically significant and that most families used the facilities frequently. Yet it was observed that the probability of a mother without schooling losing her child was two-and-a-half times that of a mother with schooling. In the town that enjoyed ample health facilities this ratio was higher still - four times and very little of this extra margin could be explained by more educated mothers sending their children to facilities elsewhere, for few made such a journey, and those who did were mostly adult men.

In another analysis of the Nigerian statistics from two surveys undertaken in 1973 in Ibadan city using 6,606 women and the other of 1,499 women in a large area of south-west Nigeria, Caldwell established that maternal education was the single most important determinant of child mortality in Nigeria. He showed that very different levels of child survivorship result from different levels of maternal education in an otherwise similar socio-economic context and when there is an equal access to the use of medical facilities. Caldwell concluded that women's education in societies such as that of the Yoruba in Nigeria could produce profound changes in family structure and relationships which in their turn may influence both mortality and fertility levels (Caldwell, J.C., 1979). Thus education may well play a major role in the demographic transition and this role may help to explain the close timing of mortality and fertility transitions.

In Ethiopia, it has been observed that education has a depressing effect on mortality (Gebretu, 1977, p. 161). In Sierra Leone, early childhood mortality was found to be negatively related to the educational attainment of the mother. It was found that the proportion of male survivors to age 2 years ranges from .874 to .769 among children whose mothers were post-primary graduates and illiterates, respectively, while the proportion of female survivors were found to be .885 and .795, respectively (Tesfay, 1977, p. 241-242). Other observations of a similar kind have been found in respect of Sudan and Zambia (Rizgalla, 1977, p. 246-273; Banda, 1977, p. 196-199).

The present analysis of early childhood mortality by maternal educational levels deals with data on the tendency of women to lose children (differentiated by women's levels of education).

5.3 Analysis of Child Mortality by Women's Educational Levels

As mentioned earlier, this analysis is based on the 1979 Kenyan Census. This provides information on educational levels and other socio-economic characteristics. Mortality data for all the regions under consideration are those based on the 1979 Census reports on the number of children still-living and the total number ever born by educational attainment of their mothers.

Appendix D provides q(2) estimates by maternal educational levels for all districts. These estimates are based on Brass estimation technique described in Chapter III of this thesis.

Although the proportions of women with secondary education or above in the educationally least advanced districts were small (See Table 5.1), marked child mortality differentials by education of mother as reported elsewhere (as in the above-mentioned regions), could still be noted. Furthermore, if there is any understatement of dead children, it is likely to be proportionately greater among the uneducated than the educated, and hence the true differences may be even greater than those shown in Appendix D.

The figures in Appendix D are well suited for analysis of differential mortality by controlling education of mother as well as relating levels of mortality to other characteristics (socioeconomic, health, demographic and disease). They were found to be necessary when attempting to determine the primacy of mother's education as a factor in depressing infant/child mortality. The index q(2) was considered suitable for analyzing current differentials in infant/child mortality because of the reasons stated

TABLE 5.1 PERCENTAGE DISTRIBUTION OF WOMEN BY EDUCATIONAL LEVELS - 1979

District	X_1	X_2	X_3
	% None	% Primary	% Secondary +
Nairobi	21.17	39.84	38.22
Nyeri	36.68	45.56	17.12
Nyandarua	45.38	28.46	10.95
Muranga	41.88	44.50	12.23
Kirinyaga	51.40	36.33	11.60
Kiambu	36.77	44.58	17.94
South Nyanza	58.02	35.17	5.96
Siaya	62.09	32.99	4.59
Kisumu	52.93	36.59	9.23
Kisii	48.09	38.85	12.08
Kakamega	51.45	37.81	10.11
Bungoma	46.14	42.33	10.85
Busia	64.57	29.06	5.77
Embu	51.70	36.43	11.22
Isiolo	87.62	8.98	2.88
Kitui	73.53	21.82	4.33
Machakos	46.43	42.98	9.82
Marsabit	95.14	3.27	1.63
Meru	56.53	33.48	9.08
Garissa	95.78	2.18	1.44
Mandera	97.90	1.18	0.40
Wajir	97.49	1.49	0.64
Kilifi	87.07	9.39	2.78
Kwale	84.37	11.56	2.83
Mombasa	45.05	32.73	19.88
Lamu	80.32	15.64	3.32
Taita Taveta	50.54	39.74	8.71
Tana River	85.94	11.68	1.79
Baringo	68.07	26.64	4.52
Elgeyo Marakwet	62.00	32.92	4.24
Kajiado	75.16	17.83	5.94
Kericho	57.74	35.06	6.24
Laikipia	55.07	35.93	8.36
Nakuru	47.99	39.63	11.27
Nandi	54.10	39.01	5.80
Narok	85.96	10.85	2.05
Trans Nzoia	55.48	35.63	7.77
Samburu	93.38	4.50	1.85
Turkana	95.92	2.53	0.60
Uasin Gishu	51.05	38.50	9.43
West Pokot	89.39	7.86	1.66

Source: 1979 Kenyan Population Census

earlier (Chapters II and III).

From Appendix D, it can be observed that the q(2) values for women with some primary education (PE) but no more, was only 64 percent of that recorded by women with no education (NE), for Kenya as a whole; while that for women with more than a primary education (SE+) was 37 percent of that of women with no schooling.

At the district level, remarkedly similar figures are shown for these two comparisons. Indeed, larger differences are indicated in Appendix D with most districts having q(2) estimates for mothers with no education (NE), more than double that for mothers with secondary education or above (SE+).

In the highest mortality district (South Nyanza), the corresponding figures for these two comparisons were 81 percent and 43 percent; while in the low mortality district (Nyeri) these figures were 62 percent and 39 percent, respectively. Among the districts with the largest recorded difference between NE and PE was Meru with PE estimate only 57 percent of that of NE while the one with the largest difference between NE and SE was Kisumu in Nyanza Province with SE estimate only 18 percent of that of NE. In other words the probability of a mother without schooling losing a child in Meru was about two times that of a mother with primary schooling and in Kisumu it was about five times that of a mother with secondary schooling and over. Most of the districts in the Rift Valley and Western Provinces had low differences as compared to other districts.

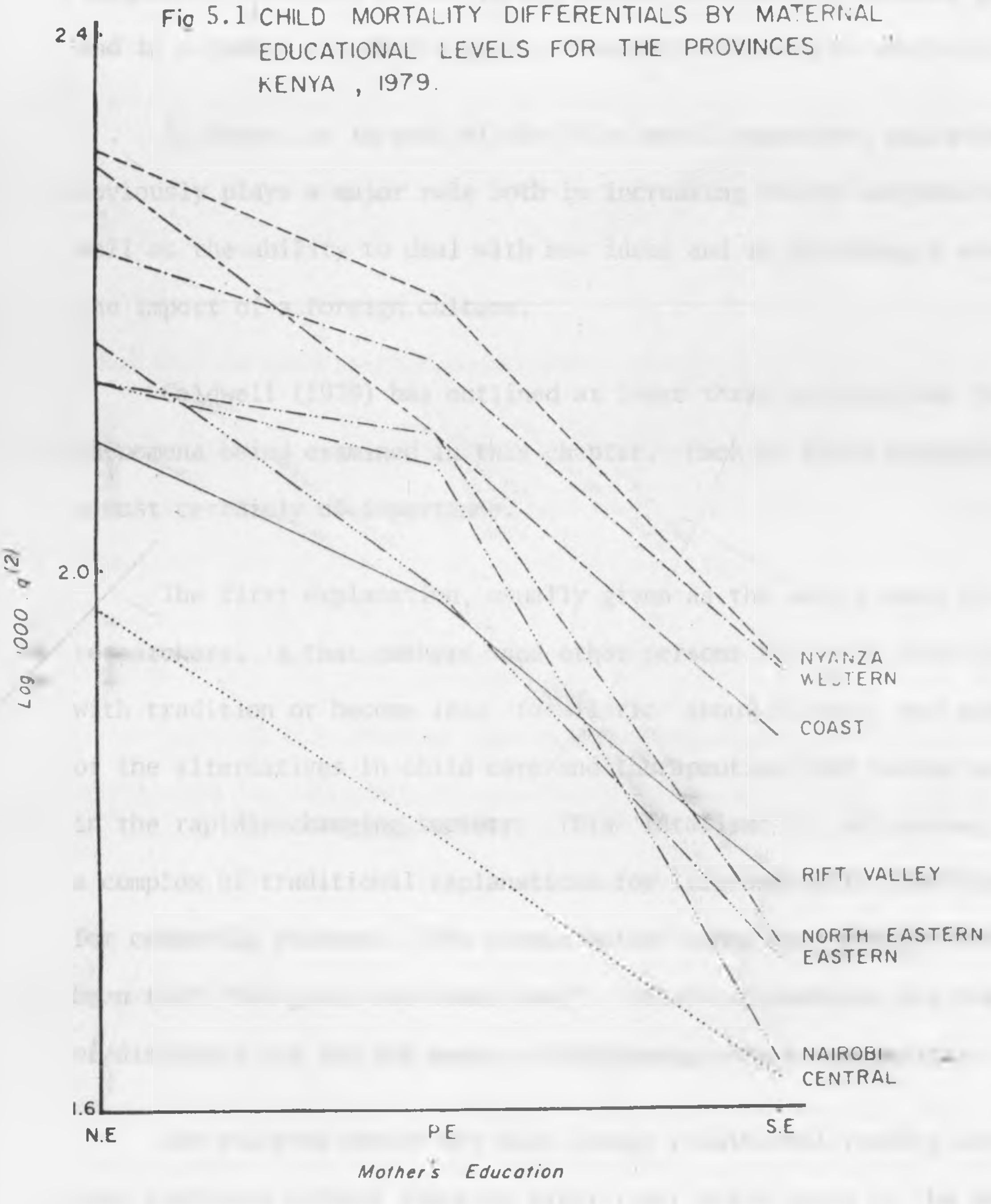
A further examination of these figures shows that steeper absolute but similar relative declines in mortality by maternal education levels were observed in those districts with high mortality than those found in the low mortality districts. One reason may be that in the low mortality districts other factors may be at work such as better health services - more hospitals, child-care clinics, health centres and health sub-centres. Another possible factor at play may be the change of attitudes towards proper health practices which may occur among women with no formal education caused by the influence of those with education. It is expected that the higher the proportion of women with more than a formal education in a district, the greater the change of such attitudes among women.

A further analysis of these figures reveals marked regional differences which persist even when maternal education is controlled. This situation has been clearly indicated by plotting the values of the function log 1000 X q(2) by maternal educational levels (Graph 5.1).

This situation is less astonishing in view of the already noted differences in the prevalence of malaria, per capita agricultural land potential and other explanatory factors among the districts (Chapter IV). Thus it can be argued that the differences in maternal educational composition does not explain the existing regional mortality differentials. A similar finding was observed in Nigeria where a study of two Yoruba villages was undertaken with and without medical facilities, respectively (Orubuloye and Caldwell, 1975). This study revealed marked mortality differentials which could not be explained by differences in educational composition.

The present findings, therefore, suggest that education does not really reduce or eliminate the infant and child mortality differentials

Fig 5.1 CHILD MORTALITY DIFFERENTIALS BY MATERNAL EDUCATIONAL LEVELS FOR THE PROVINCES KENYA , 1979.



existing among the districts. Other factors may be at work such as inequality in access to health and social services, in disease prevalence, and in a number of other aspects of society relevant to mortality.

In Kenya, as in much of the Third world countries, education obviously plays a major role both in increasing skills and knowledge as well as the ability to deal with new ideas and in providing a means for the import of a foreign culture.

Caldwell (1979) has outlined at least three explanations for the phenomena being examined in this chapter. Each of these explanations is almost certainly of importance.

The first explanation, usually given as the only reason by many researchers, is that mothers and other persons receiving education break with tradition or become less 'fatalistic' about illness, and adopt many of the alternatives in child care and therapeutics that become available in the rapidly changing society. This 'fatalism' is, of course, in reality a complex of traditional explanations for life and death, for disease, and for combating sickness. The common belief among many people has always been that 'God gives and takes away'. Other explanations for the causes of disorders and for the means of overcoming them involve rites.

The educated mother may also change traditional feeding and child care practices without imposing significant extra costs on the household. Sloan has argued that maternal education necessarily affects the household consumption of health-related goods and services (Sloan, F. 1971, pp. 17-18).

The second explanation is that an educated mother is more capable of manipulating - that she is more likely to be listened to by doctors and nurses and she is more likely to know where the right facilities are and to regard their use as a right and not a favour.

The third explanation, often regarded as the most important, is that women's education greatly changes the traditional balance of familial relationships with profound effect on child care (Christie Oppong, 1968 and Caldwell and Caldwell, 1978).

In Kenya, there are ample reasons why education which incorporates a strong element of Westernization, might reduce mortality. For instance, the authority of the school, directly challenges the traditional authority structure, especially the authority of the old people. Indeed, at present in Kenya, the old take the challenge for granted without much conflict. Everywhere in the country, the impact of schooling is so decisive because it changes not only the educated but also the attitudes of others to them.

The education of a girl, for example, is likely to make her feel her personal responsibility. She is more likely to challenge her mother-in-law and those around her who in turn are much less likely to resist the challenge. More generally, the younger woman will insist upon the wisdom of the school against the wisdom of the old. She is more likely to attempt to communicate with her husband who is more likely to accept the attempt. In all these changes the initiative taken by the woman is usually more important than that taken by the man. In fact, a range of literature has emphasized that women play major roles in family's decision-making in traditional societies (Louise S. Sweet, N. Tanner, 1974; Okonjo, K. 1978).

5.4 Conclusion

The preceding analysis has shown that there are marked differences in child mortality by educational attainment of women. The statistics for all the districts came from the 1979 Census. The proportions of children dying among women aged 20-24 for each district were converted by Brass technique into the probabilities of dying before age 2 years before relating to the educational attainment of women.

Generally, it was observed that steeper absolute but similar relative declines in child mortality by women's educational levels occurred in those districts with high mortality as compared with those observed in the low mortality districts. For example, in Kisumu District (a district in the high mortality zone), it was found that the probability of a mother without education losing a child was about five times that of a mother with secondary education or above; while in Nyeri (the lowest mortality district), the probability of a mother with secondary education or above losing a child was 2½ times smaller than that of a mother with no schooling.

The child mortality levels also suggested marked differences in the contributions of educational programs to the levels of mortality with the group with no education having a bigger impact than the other two educational groups in each district. The distributions of the estimates of child mortality levels attributable to the educational programs appears to be linear. The estimates reach a maximum in the group whose mothers have no education and a minimum among children whose mothers have secondary education or over (Appendix D). This is to be expected as the very young whose mothers have no education are prone to fatal infections due to a lack of knowledge on preventive measures by their mothers unlike those born to women who have more education.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The purpose of this study was to investigate the differential importance of macro factors for determining the levels of infant and child mortality at the district level. The investigation involved the use of multivariate regression analysis to determine to what extent health facilities, hospital beds, malaria incidence, parity of births, agriculture, women's education, urbanization, population density and kilometres of roads are significant predictors of early childhood mortality when they are considered individually or in combination.

A review of the relevant literature revealed that most of these factors have, in fact, been found to influence mortality in many situations.

In view of the conclusions and recommendations made by other researchers, especially those by Anker and Knowles (1977) in their report of mortality differentials in Kenya, the following hypotheses, stated in the null form were formulated and tested in this study.

(i) There exists an inverse association between infant and child mortality on one hand and the socio-economic and health factors such as women's education, health facilities, available hospital beds, urbanization, agriculture and kilometres of road on the other.

(ii) There exists a direct relationship between infant and child mortality on one hand and the demographic and disease factors such as parity, population density and the endemicity of malaria on the other.

In order to test these hypotheses, the 41 Kenyan districts were involved in the investigation. The 1979 Kenya Population Census data and other socio-economic, disease, demographic and health data were utilized. Proxies for each of these variables were obtained and data collected for each district.

As regards the technique used for the estimation of the level of infant and child mortality from the 1979 Census data, it was pointed out that it is more likely to underestimate the level of mortality because of possible under-reporting of infant and child deaths by the mothers. In the light of this, one can therefore accept these estimates based on the 1979 Census results as fairly accurate conservative estimates.

The t-test and univariate analysis of variance were the major statistical techniques used for testing the hypothesis. The t-test was used to assess the differences in the effectiveness of the macro factors on infant and child mortality. To test the goodness of fit of the model obtained X^2-test of variance was used.

As stated in the interpretation of the results of this study and in other relevant chapters, this study was beset by a number of limitations. In brief these limitations were:

(i) The unreliability of mortality data;

(ii) The non-linearity of some of the predictor variables considered;

(iii) The difficulty of proxying for rural income;

(iv) The lack of measures for other macro level factors such as income of the parents, religious affiliation and the degree of utilization of health facilities at the district level.

6.2 Conclusions

Within these limitations of the study the following conclusions can be drawn:

(i) In view of the child mortality estimates based on the results of the 1979 Census, the level of child mortality in Kenya is very high (125/1000) and in the case of South Nyanza District, alarmingly high (216/1000). Nyeri District with a child mortality rate of 49/1000 appears to be the best off in the whole country. In general, these estimates indicate that child mortality levels are lowest in the highland areas of Kenya and that as one moves towards the Lake Basin to the east, or towards the Indian Ocean coast to the south-west of the country, these levels increase. Several reasons have been put forward to explain this geographical clustering of high and low mortality regions.

(ii) The socio-economic factors such as women's education, urbanization, agriculture, available hospital beds and kilometres of roads were found to be inversely related to child mortality, although the regression results suggested a direct relationship between hospital beds and child mortality levels. The positive relationship exhibited between the 'population per health facility' variable and child mortality clearly suggests that health facilities are inversely related to child mortality, although the relationship was found to be insignificant.

(iii) The demographic and disease factors considered in this study, such as population density, total fertility rate and malaria, all showed a positive relationship with the child mortality levels.

(iv) Only four out of nine explanatory variables considered in this study explained 52.5 percent of the variation present in the child mortality index as compared with 59.4 percent explained by all the variables put together. These four variables include women's education, malaria, agriculture and population density.

(v) In view of the high correlations between women's education and child mortality and between malaria and child mortality as revealed by the intercorrelation and multiple regression analysis, there is no doubt that these two factors are the most effective ones influencing child mortality levels.

(vi) The regression equation obtained suggests that when the percentage cases which are malaria are reduced by 30 percent, the effect would be to reduce child mortality level by 81 deaths per 1000 births. If the percentage of women with five or more standards of education is raised by 30 percent and allowance is made for the other variables, the result would be a reduction of child mortality level by about 58 deaths per 1000 births. These results suggest that malaria control would have a tremendous impact on child mortality.

(vii) The quantitative change on child mortality level that would be brought about by changes in each of the other explanatory variables, as suggested by the regression equation, is less significant as compared with changes resulting from malaria and women's education. For instance, a 30 percent rise in urban population would reduce child mortality level by about 18 deaths per 1000 suggesting that urbanization is still an healthy phenomenon in Kenya. A 50 percent decline in total fertility rate, say from 8 to 4, would result in a decline of mortality level by about 16 deaths per 1000 births only. Furthermore, to achieve such a fall in fertility requires a lot of effort and time as it involves changing the attitudes of a society towards birth control. Similarly, the remaining variables (namely agriculture, population density, health facilities, hospital beds and kilometres of roads) were observed to have slight effect on child mortality levels.

(viii) The Kenyan district statistics analysed here show that the existing inter-district variations in the levels of child mortality result only in part from the educational differentials among these districts. Indeed, regional differentials in child mortality were seen to persist even after controlling for variations in women's educational levels. Thus women's education plays a major role only as a factor in mortality decline.

(ix) In view of the high correlation between child mortality and women's education, it can rightly be concluded that the level of mother's education and knowledge about practices of personal hygiene, sanitation, preventive measures, nutrition and the willingness to utilize health services are positively related.

6.3 Recommendations

In the investigator's opinion, the greater effectiveness of women's education and malaria are sufficiently conclusive to warrant the implementations of educational and malaria control programs. Since malaria and illiteracy among women can be eradicated easily by the application of preventive measures and by mass literacy, respectively, it appears that the attack should be directed against these two evils of human society - disease and illiteracy.

In order to bring about a decline in the level of child mortality in the country, concrete development policies should be adopted that should be accompanied by increased teaching of health practices to the rural women and a complete eradication of malaria. The non-urban areas contain over 90 percent of the population of the nation. Therefore, a much greater emphasis on health and family planning education of the rural population is urgently demanded. There must be more concentrated and intensified efforts to provide more integrated programmes in basic curative, preventive and promotive health services to reach these people.

If the educational programs are to be used as implements for reducing or controlling child mortality in the country, then these programs must be aimed at the teaching and promoting of the knowledge of personal hygiene, sanitary practices, preventive measures and the importance of good nutrition. Increasing female school enrolment, especially in the rural areas, should be adopted as an important policy measure since female education influences the health conditions of the children and consequently their chances of survival. The more educated a woman is the more aware she becomes of the health problems of her children and the steps necessary to be taken.

Moreover, if education has to produce more negative impact on mortality, then it must be accompanied by increased rates of social and economic development. Considering all Central Government expenditures on health together, spending per capita rose from 6.5 shillings in 1963/64 to 8.3 shillings in 1967/68 and sharply to 58 shillings in 1979/80. Of the six major programmes of the Ministry of Health namely curative Health; Preventive Medical and Promotive Health; Rural Health Services; Health Training; Medical Supplies Services and Medical Research, curative (hospital) development programmes have always had a bigger share of the budget. Spending per capita, for example, rose from 2.5 Shs. in 1969/70 to 15.5 shillings in 1974/75 and to 34.4 shillings in 1979/80 for curative development programmes alone. These programmes include such sub-programmes as the construction of new hospitals and the extensions and improvements of district, provincial and national hospitals. Expenditures on preventive medical and promotive health programmes which includes such sub-programmes as Communicable and Vector-borne Disease Control, Environmental Health, Family Planning/Maternal Child Health, National Health Laboratories, Health

Education and Nutrition, rose from about -/20 cents in 1969/70 to 2.5 shillings per person in 1974/75 and then sharply to 3.9 shillings in 1979/80. With adequate Preventive Health Services these figures could be reduced rather than increased.

There is an average population growth rate of about 4 percent per year as suggested by the 1979 Census; rapid expansion of urban centres; wide disparities in the distribution of health services; a severe shortage of medical manpower and financial limitations. Intensified health education services in combination with all other efforts and resources of the nation may improve the situation. Perhaps most importantly, a reduction in the number and proportion of large families would also have substantial impact.

Thus if any effective policy has to be made with the objective of reducing or controlling the present levels of mortality in Kenya, espeially in the high-mortality regions, then all the ecological, socic-economic, disease, health and demographic factors have to be taken into account. A policy which integrates all these factors, therefore, would be likely to reduce the existing inter-district differentials in mortality tremendously. It is the opinion of the investigator that such a policy should be formulated by the Government through the ministry or ministries concerned.

While the results of this research suggest that health facilities, hospital beds and fertility are less effective and do not deserve to be considered, these results are not sufficiently conclusive to oppose their immediate implementation. It seems apparent that further evidence is required before the impact of these factors on child mortality can be determined.

The results of this study would also be beneficial in the academic sphere for students and other scholars interested in mortality studies. Other types of mortality differentials in Kenya need to be investigated. These include mortality differentials within the rural communities, urban communities, high mortality regions, low mortality regions, various socio-economic groups and groups affiliated to different religions. To achieve these, micro-level studies would be necessary.

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APPENDIX A. DISTRIBUTION OF ADULT AND FEMALE POPULATION WHO ARE LITERATE (>5 Years of Education)

District	Adult Population	Adults Literate	% Adults Literate	Female Adults	Fem. Adults Literate	% Fem. Literate
Nairobi	546,696	228,099	41.72	203,432	138,006	67.84
Nyeri	234,875	129,848	55.28	126,681	59,018	46.59
Nyandarua	103,911	57,810	49.86	54,572	21,510	39.42
Muranga	308,456	141,583	45.90	168,817	64,840	38.41
Kirinyaga	145,798	66,647	45.71	75,846	26,537	34.99
Kiambu	348,896	204,180	58.52	173,289	80,576	46.50
South Nyanza	427,474	160,103	37.45	230,472	58,419	25.35
Siaya	251,931	83,623	33.19	148,682	35,869	24.12
Kisumu	263,245	113,318	43.05	134,407	42,844	31.88
Kisii	405,746	192,958	47.56	214,546	78,320	36.50
Kakamega	499,963	201,471	40.30	274,813	91,294	33.22
Bungoma	242,166	115,196	47.57	125,985	46,820	37.16
Busia	154,499	14,802	9.58	86,016	19,314	22.45
Embu	130,190	56,130	43.11	68,947	23,624	34.26
Isiolo	24,956	4,304	17.25	12,414	728	5.86
Kitui	22,925	61,601	26.84	131,924	24,500	18.57
Machakos	509,171	228,390	44.86	274,159	99,074	36.14
Marsabit	55,156	3,999	7.25	27,246	566	2.08
Meru	427,137	148,295	34.72	220,471	61,391	27.84
Garissa	68,426	4,657	6.80	30,889	875	2.83
Mandera	58,224	2,685	4.61	28,654	352	1.23
Wajir	75,965	3,317	4.37	36,612	629	1.72
Kilifi	232,542	43,314	18.63	127,518	11,033	8.65
Kwale	155,967	29,562	18.95	80,922	7,967	9.84
Mombasa	217,206	120,686	55.56	89,265	39,241	43.96
Lamu	23,628	5,147	21.78	11,390	368	3.23
Taita Taveta	74,700	30,235	40.48	38,974	8,347	21.42
Tana River	48,444	7,714	15.92	24,313	1,921	7.90
Baringo	104,966	27,795	26.48	53,221	10,290	19.33
Elgeyo Marakwet	79,306	25,019	31.55	40,325	9,553	23.69
Kajiado	75,360	20,247	26.87	37,663	6,951	18.46
Kericho	315,521	126,222	40.00	152,692	42,275	27.69
Laikipia	67,220	27,918	41.53	31,881	10,330	32.40
Nakuru	265,003	128,681	48.56	125,960	47,203	37.47
Nandi	153,102	55,650	36.35	74,063	20,005	27.01
Narok	104,431	16,765	16.05	53,463	4,453	8.33
Samburu	39,806	3,787	9.51	61,143	18,055	4.91
Trans Nzoia	126,655	49,593	39.16	21,365	1,050	29.53
Turkana	83,349	4,175	5.01	41,525	868	2.09
Uasin Gishu	154,367	67,981	44.04	72,870	24,818	34.06
West Pokot	83,063	9,861	11.87	42,543	2,703	6.35

Source: 1979 Provisional Census Results

APPENDIX B. SEX RATIOS BY AGE GROUPS (MALES PER 100 FEMALES) OF THE REGION COMPARED WITH THE SEX RATIOS OF AN AFRICAN STANDARD DISTRIBUTION AND SEX RATIO MODEL. $SR_o = 103$

District	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
1 Nairobi	100	95	84	85	151	178	225	226	278	327	282	257	181	175	115
2 Kiambu	101	99	100	97	107	111	117	94	103	103	96	98	85	92	94
3 Muranga	101	102	101	98	79	76	84	70	75	79	74	83	74	95	87
4 Nyeri	101	102	99	101	89	79	83	74	78	76	74	82	72	95	80
5 Kirinyaga	101	100	100	101	100	95	90	83	75	90	80	92	81	104	89
6 Nyandarua	100	103	105	100	89	84	76	65	97	99	96	105	101	116	90
7 Kisumu	98	99	102	92	87	93	107	91	94	89	94	99	111	149	137
8 Siaya	98	100	106	93	61	52	54	47	51	54	69	79	90	128	125
9 South Nyanza	100	101	109	98	79	70	75	68	75	76	92	97	122	165	151
10 Kisii	100	99	102	91	85	84	87	77	87	93	97	105	97	125	100
11 Kakamega	99	99	101	93	77	75	76	62	70	71	81	90	84	112	112
12 Bungoma	99	98	102	98	92	89	87	81	90	92	97	91	83	104	102
13 Busia	99	100	102	88	69	66	71	69	72	74	93	97	95	126	127
14 Mombasa	101	98	100	100	127	151	170	176	194	191	173	152	128	127	119
15 Kilifi	97	103	110	86	61	75	70	76	81	93	97	116	112	135	137
16 Kwale	98	100	73	92	72	84	83	90	98	115	120	128	122	131	121
17 Lamu	95	102	110	103	96	111	111	121	107	136	99	140	89	125	110
18 Tana River	104	100	114	100	92	89	89	101	103	115	94	134	112	160	116
19 Taita Taveta	101	98	102	90	82	89	90	90	90	102	94	94	100	113	120

Cont'd .../...

District	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
20 Laikipia	99	102	112	107	110	105	113	103	119	124	113	124	117	126	118
21 Narok	98	101	116	100	81	87	85	95	101	104	105	122	109	136	117
22 Kajiado	49	103	114	98	94	99	93	96	103	121	110	115	105	113	102
23 Turkana	98	104	115	114	92	83	78	91	104	127	127	144	144	167	178
24 Samburu	100	97	104	98	75	73	76	81	79	105	112	112	91	102	80
25 Nakuru	101	100	102	95	108	111	121	131	129	129	119	124	115	130	113
26 Baringo	101	99	106	101	91	92	101	89	92	98	94	110	108	114	112
27 Kericho	101	100	100	97	104	115	123	106	108	110	104	112	102	120	103
28 Uasin Gishu	101	99	102	95	109	114	124	108	127	126	129	133	109	135	117
29 Nandi	99	99	101	94	108	107	113	108	115	112	123	113	97	120	105
30 Trans Nzoia	99	100	100	97	97	105	107	107	117	119	142	142	119	163	126
31 Elg. Marakwet	98	100	101	98	90	98	104	83	86	88	93	109	106	124	126
32 West Pokot	98	101	107	103	81	88	88	89	95	100	101	106	122	132	120
33 Embu	100	101	100	97	86	90	84	82	87	92	74	91	74	105	93
34 Meru	101	100	101	94	89	94	95	87	88	96	90	109	98	117	105
35 Isiolo	103	101	114	93	106	108	97	103	97	138	86	110	104	131	73
36 Kitui	99	100	103	94	64	59	58	62	66	78	68	87	85	95	85
37 Machakos	101	101	102	102	84	75	82	70	82	77	68	89	89	115	102
38 Marsabit	102	102	109	106	103	94	88	105	100	131	104	117	105	110	105
39 Garissa	103	108	117	125	140	113	97	104	114	148	124	172	140	195	111
40 Wajir	113	114	116	113	112	98	90	96	109	135	113	135	121	129	106
41 Mandera	105	92	114	110	108	101	90	100	102	127	93	118	102	155	93
SR Model SR_o=103	100.5	99.7	99.6	99.7	99.7	99.7	99.5	99.1	98.3	96.9	94.7	91.5	87.9	84.2	69.7
African Standard	99	103	113	97	83	85	87	99	101	113	108	114	103	106	104

APPENDIX C. SELECTED SOCIOECONOMIC, HEALTH, DISEASE AND DEMOGRAPHIC VARIABLES FOR CORRELATION ANALYSIS

District	1000 q(2)	Percent Urban Population	Population Per Health Facility	Per Capita High Potential Agr. Land	Total Fertility Rates	Percent Malaria Cases	Percent Female Adults Literate	Beds Per 1000 popu- lation	Kms. of Roads Per 1000 Km^2	Persons Per Sq. Km
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Nairobi	93	100.00	5900	-	5.45	-	67.84	4.52	-	1210
Kiambu	70	7.50	30000	0.289	8.34	4.53	46.50	0.92	267	280
Muranga	68	2.70	14000	0.289	8.80	11.29	38.41	0.64	204	261
Nyeri	49	8.39	13600	0.329	8.60	1.35	46.59	1.00	131	148
Kirinyaga	82	2.71	10600	0.336	9.16	14.35	44.99	0.69	151	262
Nyandarua	64	4.82	12000	1.136	9.88	1.74	39.42	0.90	128	66
Kisumu	199	32.47	36000	0.451	7.49	34.71	31.88	1.03	173	230
Siaya	211	0.85	24000	0.451	7.68	32.62	24.12	0.44	173	188
South Nyanza	216	1.93	31500	0.692	8.17	31.56	25.35	0.32	150	143
Kisii	101	3.54	42000	0.253	9.90	20.91	36.50	0.48	212	395
Kakamega	143	3.42	45700	0.315	8.79	31.03	33.22	0.26	176	294
Bungoma	140	8.91	36700	0.502	9.36	30.38	37.16	0.31	138	163
Busia	198	8.32	28800	0.547	7.76	27.60	22.45	1.27	197	183
Mombasa	120	99.84	4300	-	5.43	18.29	43.96	2.17	201	1622
Kilifi	212	7.99	13000	0.241	7.53	26.09	8.65	0.37	57	34
Kwale	190	2.90	13600	0.437	7.49	23.79	9.84	0.65	61	34
Lamu	200	25.24	2000	0.165	7.94	17.55	3.23	5.30	22	6
Tana River	181	5.80	5600	0.790	8.10	28.22	7.90	2.71	14	2
Taita Taveta	116	4.95	8200	0.284	8.11	23.93	21.42	1.11	23	8

Cont'd .../...

District	1000 q(2)	Percent Urban Population	Population Per Health Facility	Per Capita High Potential Agr. Land	Total Fertility Rates	Percent Malaria Cases	Percent Female Adults Literate	Beds Per 1000 population	Kms. of Roads Per 1000 Km^2	Persons Per Sq. Km.
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Laikipia	77	14.19	9200	0.966	9.00	5.97	32.40	1.07	55	13
Narok	95	10.99	8700	4.398	8.06	13.71	8.33	0.89	46	13
Kajiado	75	8.10	5700	0.148	8.03	18.70	18.46	1.90	39	7
Turkana	133	13.56	83000	0.084	3.77	13.84	2.09	0.31	13	2
Samburu	77	16.25	22000	1.820	6.91	14.08	4.91	0.66	20	4
Nakuru	97	25.38	9100	0.557	8.77	9.16	37.47	3.01	127	90
Baringo	171	6.75	5200	0.814	8.87	16.25	19.33	0.35	61	30
Kericho	91	5.94	18400	0.600	9.00	14.92	27.69	0.31	139	161
Uasin Gishu	92	16.52	13500	1.087	8.83	19.81	34.06	0.50	136	89
Nandi	110	0.99	21500	0.782	8.61	13.84	27.01	0.46	134	109
Trans Nzoia	114	10.94	19000	0.802	9.13	17.50	29.53	0.97	135	124
Elgeyo Marakwet	127	0.00	19000	0.699	7.95	13.23	23.69	0.36	100	65
West Pokot	188	3.06	14000	0.649	8.17	23.63	6.35	1.53	72	17
Embu	83	6.15	11600	0.251	9.52	16.67	34.26	0.71	123	96
Meru	75	9.01	23000	0.290	8.15	15.71	27.84	0.30	69	83
Isiolo	127	26.17	5500	0.000	6.69	27.00	5.86	1.30	14	1
Kitui	148	1.45	15000	0.144	8.46	24.98	18.57	0.50	41	15
Machakos	98	9.81	21500	0.122	8.81	19.63	36.14	0.67	66	72
Marsabit	130	20.39	9300	0.042	6.67	18.76	2.08	2.41	14	1
Garissa	131	15.62	10000	0.000	8.25	23.21	2.83	2.35	12	2
Wajir	129	14.24	10800	0.000	9.65	16.42	1.72	1.36	11	2
Mandera	146	15.88	34300	0.000	7.76	19.82	1.23	0.63	18	3

APPENDIX D CHILD MORTALITY INDICES, q(2), BY EDUCATION OF MOTHER, KENYA, 1979

District/ Province	Education of Mother				Ratio of Indices	
	All Mothers	NE	PE	SE	PE/NE	SE/NE
KENYA	0.125	0.163	0.104	0.061	0.64	0.37
NAIROBI	0.093	0.138	0.101	0.053	0.73	0.38
CENTRAL	0.067	0.094	0.063	0.042	0.67	0.45
Kiambu	0.070	0.103	0.069	0.045	0.67	0.44
Muranga	0.068	0.087	0.065	0.047	0.75	0.54
Nyeri	0.049	0.079	0.049	0.031	0.62	0.39
Kirinyaga	0.082	0.101	0.073	0.041	0.72	0.41
Nyandarua	0.064	0.093	0.060	0.039	0.65	0.50
NYANZA	0.174	0.204	0.158	0.085	0.77	0.42
Kisumu	0.199	0.240	0.175	0.094	0.73	0.18
Siaya	0.211	0.237	0.190	0.123	0.80	0.52
South Nyanza	0.216	0.246	0.199	0.107	0.81	0.43
Kisii	0.101	0.129	0.088	0.054	0.68	0.42
WESTERN	0.152	0.173	0.142	0.086	0.82	0.50
Kakamega	0.143	0.161	0.133	0.078	0.83	0.48
Bungoma	0.140	0.162	0.138	0.087	0.85	0.54
Busia	0.198	0.215	0.180	0.118	0.84	0.55
COAST	0.177	0.200	0.126	0.075	0.63	0.38
Mombasa	0.120	0.138	0.119	0.078	0.86	0.57
Kilifi	0.212	0.223	0.135	0.066	0.61	0.30
Kwale	0.190	0.200	0.148	0.068	0.74	0.34
Lamu	0.200	0.225	0.108	0.037	0.48	0.16
Tana River	0.181	0.186	0.170	0.119	0.91	0.64
Taita Taveta	0.116	0.139	0.110	0.057	0.79	0.41
RIFT VALLEY	0.108	0.125	0.094	0.058	0.75	0.46
Laikipia	0.077	0.087	0.071	0.054	0.86	0.62
Narok	0.095	0.097	0.088	0.039	0.91	0.40
Kajiado	0.075	0.076	0.073	0.055	0.96	0.72
Turkana	0.133	0.137	0.150	0.076	1.09	0.55
Samburu	0.077	0.075	0.100	0.064	1.33	0.85
Nakuru	0.097	0.119	0.091	0.051	0.76	0.43
Baringo	0.171	0.211	0.113	0.065	0.54	0.31

Cont'd .../...

District/ Province	Education of Mother				Ratio of Indices	
	All Mothers	NE	PE	SE	PE/NE	SE/NE
Kericho	0.091	0.101	0.085	0.046	0.84	0.46
Uasin Gishu	0.092	0.107	0.084	0.061	0.79	0.57
Nandi	0.110	0.122	0.105	0.069	0.86	0.57
Trans Nzoia	0.114	0.124	0.110	0.075	0.89	0.60
Elg. Marakwet	0.127	0.156	0.108	0.052	0.69	0.33
West Pokot	0.188	0.201	0.118	0.043	0.59	0.21
EASTERN	0.103	0.128	0.096	0.051	0.75	0.40
Embu	0.083	0.107	0.074	0.046	0.69	0.43
Meru	0.075	0.099	0.056	0.035	0.57	0.35
Isiolo	0.127	0.134	0.101	0.053	0.75	0.40
Kitui	0.148	0.162	0.120	0.092	0.74	0.57
Machakos	0.098	0.136	0.092	0.053	0.68	0.39
Marsabit	0.130	0.135	0.107	0.018	0.79	0.13
NORTH-EASTERN	0.135	0.139	0.120	0.043	0.86	0.31
Garissa	0.131	0.139	0.119	0.045	0.86	0.32
Wajir	0.129	0.130	0.107	0.022	0.82	0.17
Mandera	0.146	0.151	0.119	0.064	0.79	0.42

N.B. NE - No Education
PE - Primary Education
SE+- Primary Education and above

Source: Computer Printout

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