MEDICAL TECHNOLOGY, SOCIO-ECONOMIC STATUS, DEMOGRAPHIC FACTORS AND CHILD MORTALITY: THE CASE OF CHILD MORTALITY DIFFERENTIALS IN NAIROBI

by

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DECLARATION

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

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ABSTRACT

Mortality differentials in Nairobi (city) are of worldwide interest not only because of their importance to Kenya itself but perhaps because of their implications for other nations at or approaching Kenya's stage of urban and economic development. It is apparent from the present study that mortality levels have declined substantially on average. But differentials among social economic groups continue to persist. Overall the study shows the following:

1) Ward variations are extremely large, with a range of 8 mortality levels (20 years of life ecpectancy difference), between the lowest socio-economic areas and the better off middle income wards.
2) Women born into higher classes have lower mortality among their children. The relationship with social class largely works through the amount of education that the father and mother receives. In this study we found that educational levels correlate quite highly with mortality levels.
3) To survive in a city like Nairobi one must have at least some kind of employment and the level of employment depends on the level of education attained. It follows from this that levels of employment and income should have a substantial impact on mortality experience of Nairobi residents.

4) Immigration from high mortality areas has a substantial impact on mortality levels in Nairobi with a correlation coefficient of -0.65. This clearly implies that some of the deaths, actually, a reasonable portion is that which occur elsewhere.

In general possible future declines in mortality can be anticipated if average standards of living (in terms of better housing, education, nutrition, etc.) are improved as well as access to medical facilities especially to the poor and unemployed immigrants.

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CHAPTER 1

INTRODUCTION

From any point of view, be it social or economic or even psychological, the death of an infant or small child represents one of the most costly of human experiences. Every human birth is a unique event and the cost of the death of a child to the family and friends is in psychological terms, of course, inestimable. From a social perspective, a high infant death rate colours the attitudes and perspectives of a whole society regarding the "value of a child". In communities with very high death rates, people tend to place a low value on a new life which has uncertain chances of reaching a productive adulthood. Finally looking at it from the economic cost of a prematurely terminated life, costs are indeed considerable; for example, mother's time spent during pregnancy and nursing a child who does not live past early childhood, are from economic perspective, largely wasted resources.

Regarding the level of mortality in Nairobi itself one can only make rough estimates based on a number of indirect techniques and indicators, all of them crude. The justification for using such uncertain statistics is that, in Gunnar Myrdal's words "it is better to paint with a wide brush of unknown thickness than to leave the canvas blank". In addition from an interpretative perspective overall estimates of infant and child mortality mask major variations within a heterogeneous society such as the city of Nairobi. For example, an overall infant mortality rate for Nairobi disguises the fact that there are major differences in infant mortality between infants whose mothers have higher education as compared to those who have none or low education. These differences can reflect a number of other factors, including differential access to health care, knowledge about child care and economic resources. The examination of such intervening variables is the aim of this study.

1:1 Objectives of the study

(1) The study intends to describe child and infant mortality levels in Nairobi, and to analyse any that may be observed.

(2) If mortality differentials exist, then the independent effect of socio-economic, environmental, demographic and other potential explanatory variables will be examined.

1:2 Statement of the problem.

It is the central thesis of this research that despite the modern technological achievements of Nairobi city there still continue to exist mortality differentials due to structural inequalities in socio-economic conditions. However, there is no general consensus among scholars as to the existence of a causal relationship between mortality and socio-economic status. One school of thought asserts that mortality declines are a consequence of technological importation to the less developed countries, whereas another school contends that socio-economic variables determine mortality at an individual level. But for practical purposes both factors have contributory effect in determining levels of mortality and the whole relationship can be reduced to a simple formula as below:

$$Y = A + B_1\text{Tech} + B_2\text{Living conditions} + B_3(\text{Tech} * \text{Liv. Cond}).$$

Where Y=Mortality levels

A = Intercept

B_1 B_2 B_3 ... = Coefficients of the respective determinants.

- In this relationship much of the weight goes to the interaction term (Tech + Liv. Cond).

Those who advocate technological importation as a means of encouraging mortality decline in less developed countries tend to ignore socio-economic factors. On the other hand technological importation is discounted by supporters of a socio-economic interpretation because there are those causes of death like poor sanitation, malnutrition, diarrhoea ... that are not amenable to medical technology. Actually they are causes or rather weakening agents leading to sickness and even death, predominantly among the poor. Moreover it is argued that socio-economic variables are of immediate significance in a society that is plagued by socio-economic inequalities.

This is not denying the contribution of medicine in reducing chances of dying in a community, but rather to bring to light, that in cases where income differentials exist it means that at the same time differential access to technology prevails.

Muwonge (1980) in his study on policy and pattern of low income settlements in Nairobi examined the structural conditions of the low income groups. He found that the majority of people in Nairobi city cannot afford a decent house. Estimates made in 1977 indicate that the average income is K.Shs.280 a month and some 70 percent of the population earns less than K.Shs.500 a month (U.S. $1 = K.Shs.8).[1/] The official minimum cost of a two room house with kitchen and toilet plus shower is K.Shs.35,000 and requires a loan repayment of K.Shs.400 per month. This high standard of housing costs is an indication of the genuine high cost of living in Nairobi. As a result of these costs almost half of the Nairobi population live in congested circumstances with inadequate provision of ablution facilities, drainage, refuse disposal ...; similar circumstances are described by Mabogunge (1968, 235) in the city of Lagos (Nigeria). Whether

1/ "Housing for lower income groups - economic aspects", report presented by the Housing Research and Development Unit, University of Nairobi, to a seminar at the University, 9 May, 1977.

Nairobi or Lagos, African cities have experienced similar pressure in terms of resource distribution. Marginality in developing countries is a colonial legacy of segregation which denies the low income groups access to key services and facilities. The inheritance of the colonial structure accompanied by rapid urbanization and industrialization in the few urban centres has led to the growth of slums that are characterized by unhygienic conditions and an inadequate standard of living. This inheritance of income differentials has been maintained by African middle and upper classes for many years after independence. From independence till 1982, income differentials in African countries have been widened as compared to the situation in the preindependence era. The disadvantaged group in urban areas like Nairobi live in poor living conditions which apparently put them in high risks of morbidity which is translated into higher mortality rates. Hence, the proposed study intends to look at the mortality differentials between marginal areas of Nairobi and middle income groups based on the following theoretical perspectives.

1:3 Theoretical perspective and literature Review

In this study, mortality in a population is a function of the frequency of illness (incidence) and the probability of dying of the sick person. Health and disease are two moments of the same dynamic process. Death as an individual phenomenon has biological determinants whose mechanisms are the etiopathogenesis of the disease. But this biological conception is unable to explain by itself mortality considered at a collective level. The multi-causal approach of epidemiology has permitted the description of the distribution and cause of disease in a population. According to the epidemiologic conception, health-disease-death is a process depending on the balance between man, various external pathogenic factors and the physical, biological and social-environmental factors. Several studies have shown the relation of disease and death with variables such as income, diet, sanitation, education, medical care, etc. It has been shown also that all these independent factors in their turn are closely correlated with one another. In fact the unequal distribution in the population of all these components of the level of living are but the visible expression, the measurable link, of a causal chain grounded in the socio-economic and political organization of a particular society.

In the post World War II period most developing countries have experienced a dramatic decrease in mortality rates. The general consensus of opinion is that this decrease was largely independent of socio-economic factors and was mainly due to improved medical technology, disease control and increased availability of medical facilities. But there are some who disagree with this position, arguing instead that socio-economic factors have played and continue to play an important part in the reduction of mortality rates in less developed countries.

Eduardo E. Arriaga (1969) argues that at present, regardless of the stage of development of a country, certain inexpensive public health and medical techniques can be applied. These include health measures such as the eradication of disease vectors, chlorination of drinking water and good sewage systems, as well as vaccination, dietary supplements, use of new drugs and better personal hygiene. Arriaga claims, they need not be developed locally, as these factors can be imported. However, this position is contradicted by recent infant and child mortality findings in large areas of the third world which indicate a slowing down in the rate of mortality decline, very possibly if not probably enroute towards stabilization at levels significantly higher than those now prevailing in the West.

This controversy creates a dispute over whether the initial rapid decline of mortality has been principally a by-product of a social-policy technical change or whether it was produced primarily by economic "development", as reflected in private standards of Nutrition, Housing, Clothing, Transportation, Water Supply, Medical Care and so on.

Some demographers have generally favoured the social-policy technical change interpretation of mortality decline.

As evidence they have cited primarily the unprecedented rate of mortality reduction in many LDCs and certain dramatic examples of effective government intervention, most notably in Sri Lanka and Mauritius. Many specialists in international health (Frederickson, 1961, 1966, a.b. Marshall ...) and some medical historians focusing primarily on western populations (Mckeown and Record, 1962) have opposed this interpretation, usually claiming that technical intervention has been largely inaffective or insufficiently widespread to account adequately for the decline in mortality.

Kuznets (1975), and Coale and Hoover (1958) have argued that in one sense the distinction between economic development and public health interventions created a false dichotomy. Development itself strengthens the nation - state, improves communication among nations and hence facilitates the transfer of medical technology and routinizes scientific advance. While this position is unassailable, it leaves unanswered the question of whether mortality decline was primarily a product of changes in private consumption or of public programmes and technical change, regardless of whether the latter were in turn produced by economic development in its broadest sense. Even if public programmes and technical changes were merely intervening variables in the relation between mortality and development, the importance of their role remains to be identified.

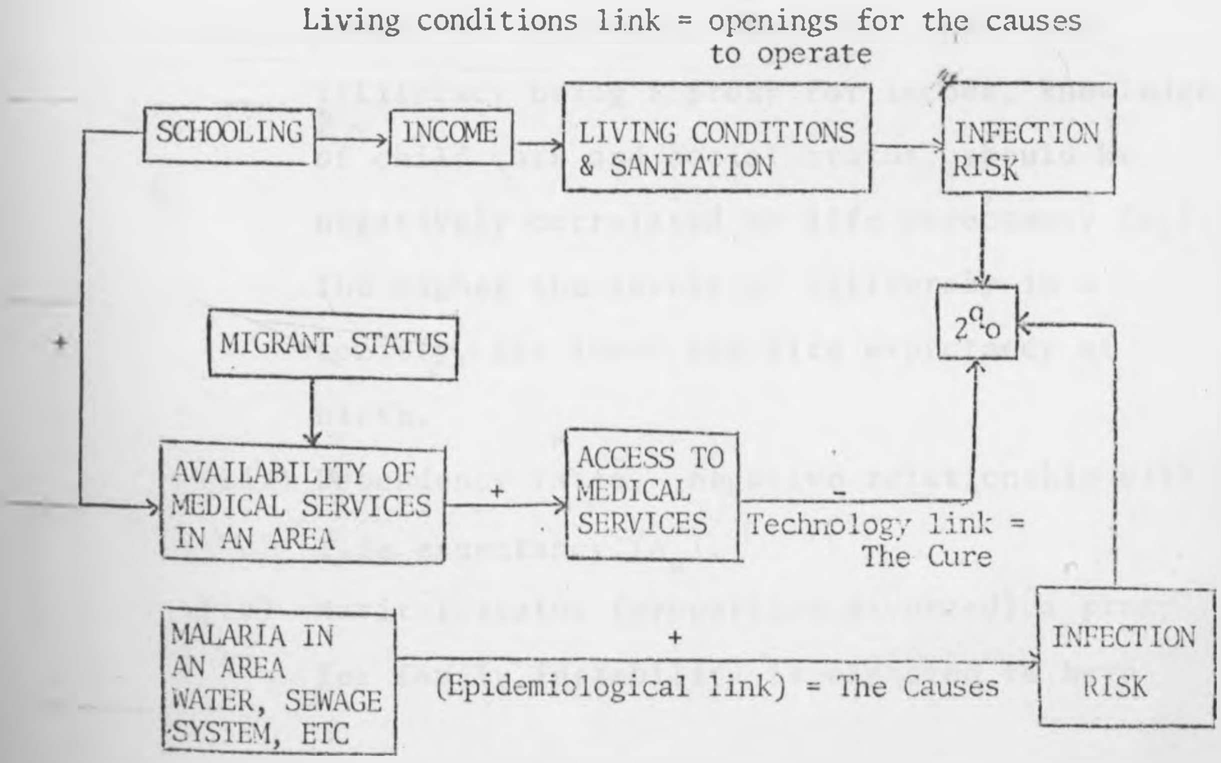
In an attempt to clarify the issue, Preston (1972) offered an explanation based on the effect of private living standards independent of the National level of economic development. According to Preston, mortality experience of a family earning $10,000 and a family earning $100 is independent of the average income of the whole country. In other words, even if a country at global level is rich and has sophisticated medical facilities it does not imply that everybody has equal access to the wealth and the facilities. This is to say that for any given level of income life expectancy can be increased significantly if there is a fair share of the National cake. Further studies of mortality differentials carried out among individuals by social or economic class in countries like India and the United States consistently reveal lower mortality rates among the upper classes (Kitagawa and Hauser, 1973; Vaidyanathan, 1972). Although studies of this kind have been attempted, the role of individual private living standards in creating the pattern of international mortality differentials is difficult to assess. But at a macro level, as this study has attempted to do, plausible techniques can be used to test empirically the impact of private income, as expressed in standards of living, on mortality.

Finally, it is argued that mortality in Nairobi is socially determined and should be studied within the context of a social theory. The root of the process lies in the way in which man transforms natural resources and establishes relations with other men in order to produce and appropriate the resulting product. This process is fundamentally a social one and expresses itself in a given socio-economic formation as a combination of different modes of production. In a situation where freedom to own factors of production is allowed, naturally, differences of material ownership emerge, creating distinct classes within a given society. When such a situation arises, certain groups of people tend to be more advantaged, and it becomes a dynamic process from generation to generation, creating well defined classes within that social system. This difference in the level of living of the various social sectors of a society more often than not, influence the occurrencence of sickness. The argument here is that susceptibility to sickness, leading to death depends on the economic status of one in a society. Susceptibility to disease is one thing and to get treatment is quite another. This creates another relationship, in that access to treatment depends on the income bracket of an individual.

In this explanation, the existence of biological determinants in the process, (health-disease-death) is not being denied in any way. The idea is rather to articulate biological factors within a social context - on the assumption that social causes can bring about and transform biological determinants (e.g. natural genetic weaknesses). Socio-economic factors play an important role in the genesis of mortality in developing countries. For example in Latin American countries, where high infant mortality prevails, this is linked to preventable causes such as malnutrition, diarrhoea and other infectious diseases.

Using this theoretical perspective, the present writer hopes to develop a conceptual model for this study. In any scientific study a conceptual model is of significant utility for it is through it that the researcher mirrors or rather reflects his findings. It is for this important reason that the following model is suggested.

1:4 Conceptual model of the research



The above conceptual model suggests the following hypotheses:

1. That mortality differentials (infant and child mortality) between high and low income groups in Nairobi will be found and that the relationship will be inverse.

2. That mortality differentials are influenced by the distribution of the following factors:

   (i) in-Migrants from high mortality regions or rather malarial regions. This variable is expected to have a positive relationship with chances of dying (probability of dying), or rather a negative relationship with life expectancy (e_o).

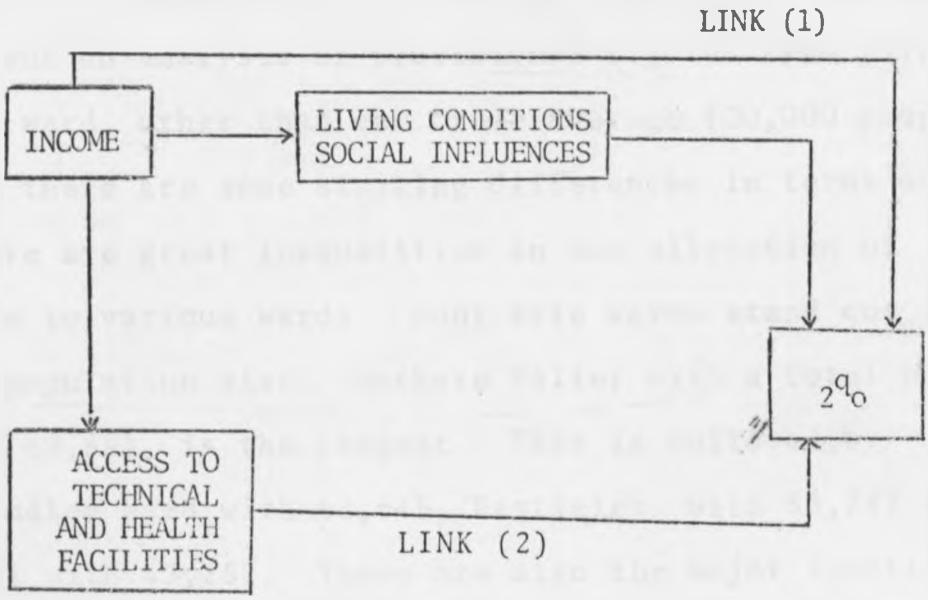
   (ii) Levels of education especially levels of illiteracy being a proxy for income, knowledge of child care and social status, should be negatively correlated to life expectancy (e_o). The higher the levels of illiteracy in a society, the lower the life expectancy at birth.

   (iii) Dependency ratio - negative relationship with life expectancy (e_o).

   (iv) Marital status (proportion divorced) a proxy for family instability is expected to have a negative relationship with mortality levels.

(v) Density per square unit and density by dwelling unit, is expected to have a negative relationship with life expectancy (e_o).

3. That access to health facilities has an influence on mortality levels. Actually health facilities in a free economy are income dependent - which can be portrayed diagramatically as below:



Link (1) - starting from income implies the risk differentiation.

Link (2) - starting from income through health facilities implies cure differentials.

It is hoped that the brief account of the hypotheses stated above will be of great assistance to the understanding of the study. Below an attempt will be made to give a concise account of the area to be studied, as well as, elaboration on definitions of the variables in the study.

1:5 The study area and some definitions

The 1979 Kenya census provides the basis for the analysis. The unit of study within the city of Nairobi is the enumerated ward: the best estimate of its average population size is 20,000. But on analysis of provisional figures from 1979 census by ward, other than the crude average (20,000 people per ward) there are some striking differences in terms of size, there are great inequalities in the allocation of population to various wards. Four main wards stand out in terms of population size. Mathare Valley with a total population of 69,691, is the largest. This is followed by Kibera/Woodley ward with 62,645, Eastleigh with 53,747 and Kariobangi with 43,252. These are also the major locations of Nairobi that are overcrowded. In the second category are medium sized areas, including Nairobi West/South, Riruta, Kangemi, Parklands, Roysambu, Ruaraka-Kasarani and Dandora wards. The third category consists of many of the wards of Eastlands and other areas of Nairobi (see Map 1 overleaf).

To establish mortality levels the experience of women aged 20-49 was selected. The socio-economic, demographic

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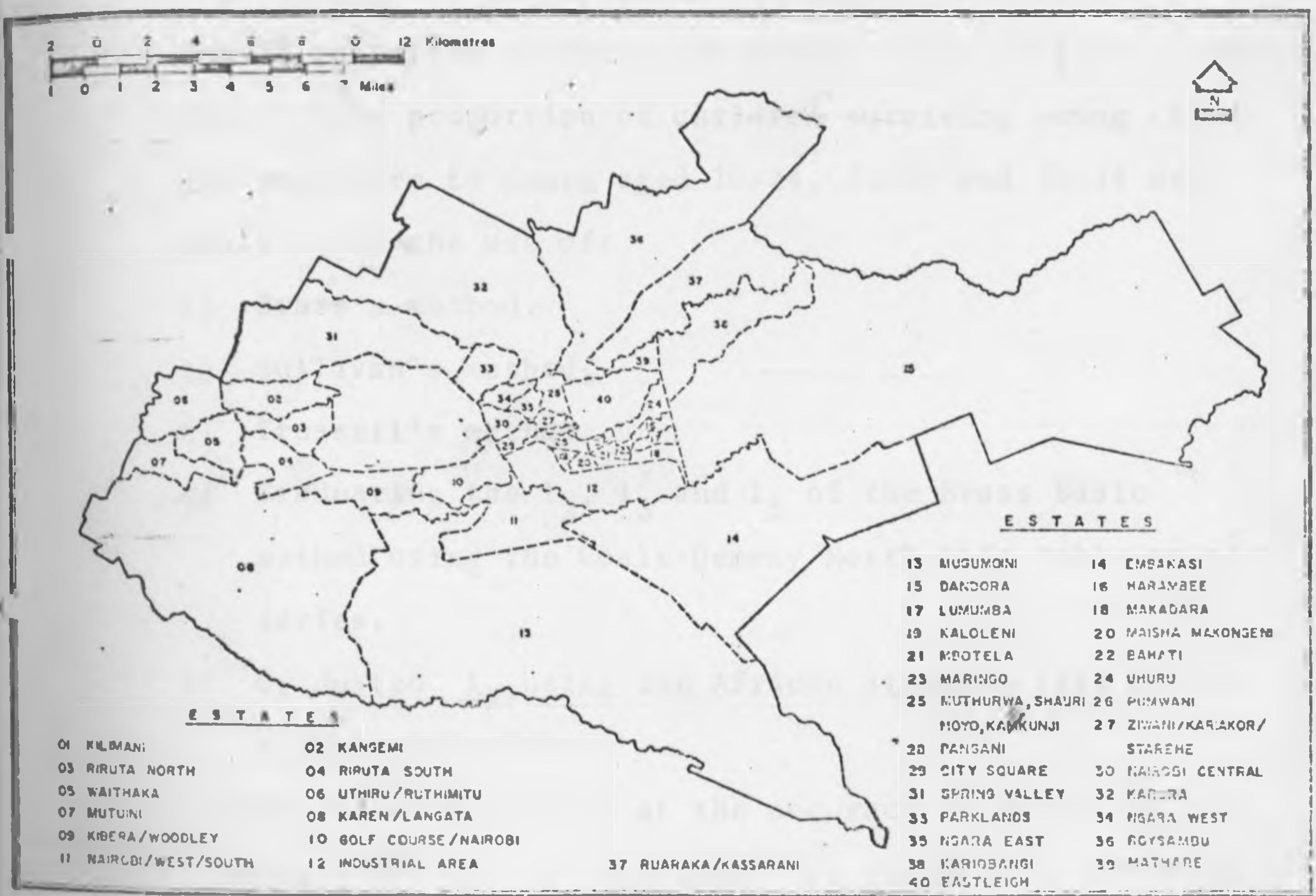
NAIROBI : RESIDENTIAL ESTATES. (1)



and environmental data was selected from the census data.

Some definitions

1. Dependent variable

In this study the dependent variable is mortality (child mortality levels). To measure this variable, 1979 data on the proportion of children surviving among children ever born to women aged 20-24, 25-29 and 30-34 were analysed by the use of:

a) Brass's method.

b) Sullivan's method.

c) Trussell's method.

d) Graduating the l_2, l_3 and l_5 of the Brass Basic method using the Coale-Demeny North life table model series.

e) Graduated l_2 using the African standard life tables developed by Brass.

- There is need to look at the accuracy of mortality data using a variety of techniques for purposes of arriving at plausible estimates. We obtained estimates of the probability of dying to the exact ages 2, 3 and 5. These values correspond to $_xq_o$ life table functions, $_2q_o$ and $_5q_o$. From $_xq_o$ we can also arrive at l_x.

2. Independent variables:

The independent variables thought to determine the above dependent variable are household level factors, or rather intermediate variables, on which the socio-economic determinants operate directly to affect morbidity. At this level it is very important to define what we mean by socio-economic determinants before definitions of social economic variables are given.

a) Social-economic factors:-

Here generally we are concerned with a broad spectrum of elements which determine man's interaction with external conditions; his resistance to inimical forces of nature, his approach to the economic struggle to supply himself with living needs, his position in society, participation in group behaviour and attitude to social life. We regard this whole process of adaptation to external stresses as a reflective of health; we regard failure to adapt as ill-health; we focus upon this process as the mechanism of mortality variation. There are numerous distinct elements in the environment which influence this process of adaptation. The mode of employment and the associated working conditions; intelligence and educational attainment and other elements in the level of living - nutrition, clothing, housing, access to medical care and other services which foster well-being even entertainment and sport - most of which are purchaseable and therefore related to income. Then too, there is the cultural background, religion, social customs, art forms and modes of emotional expression.

In essence when one talks about socio-economic factors, one is actually talking about the level of living. To establish an index for this is quite a problem for there are many intervening variables that influence and determine levels of living. The United Nations has concerned itself very much with this problem and has organized studies and conferences culminating in a Report of a Committee of Experts convened by the Secretary General (1954). The U.N. report which has received futher studies by International organizations has in general terms proposed twelve components: health, food and nutrition, education, condition of work, employment, sanitation, aggregate consumption and savings, transportation, housing, clothing, recreation, social security and human freedom (B. Benjamin and H.W. Haycocks, 1970). From these proposed components of levels of living we have chosen a few in this study as follows:

a) Educational attainment - this is a proxy for income, employment and aggregate consumption and even health.

b) Zero years of education as a proxy for housing and sanitary conditions.

c) Migration as a proxy for access to medical facilities.

Socio-Economic variables

1. Education

Of the socio-economic variables, education has recently received increased attention because of its inverse relationship to childhood mortality as well as to the magnitude of its presumed effect.[1/] In this study we derived information on education from the 1979 Kenya census. And for purposes of this analysis we have chosen to consider those women 7+ years of schooling, percent illiterates in each ward (zero years of schooling) and percent males with 9+ years of schooling as our independent variables. Other levels of education for example, 1-4 years, have been left out because there is a very high correlation between these levels and the ones considered. When this happens certain influences of some variables may be concealed if all are considered in the regression model.

2. Density per hectare by ward:

Density here is considered to measure the level of congestion by unit of land as opposed to occupancy rate which is density by dwelling unit. With density per hectare the importance is based explicitely on ecological analogy.

1/ Lincoln C. Chen, "Child Survival: Levels, Trends and Determinants". Department of Population Science, Harvard School of Public Health, Boston, (Mass 02115, January 1981).

But when one uses such statistics it should be treated cautiously since average population density per hectare is rather meaningless statistics within urban areas as it is so dependent on whether the administrative unit is largely coincidental with built up area or extends some way beyond. Although this variable contains this weakness we felt it may be important to consider it since there is no information on occupancy rate.

3. Migration from malarial regions 12 months before the 1979 census

Environmental conditions can have an important effect on mortality rates depending on whether or not the environment is "receptive" to various disease organisms and their carriers. In relation to this, Nairobi being the only Kenyan city and therefore attracting people from various quarters of the country has a very high immigration rate of people originating from varied environmental conditions. It will therefore be of paramount importance to examine whether Nairobi's mortality level and variations are influenced by in-migrants from malarial regions. Secondly, this variable will assist to measure mortality levels that are typical of Nairobi experience and not transfered mortality which may have happened elsewhere. Thirdly, the significance of this variable will show how much the high expertise and facilities of Nairobi have succeeded in combating transferred morbidity.

that is if the death occurred in Nairobi and hence measure the importance of the duration an individual is exposed to Nairobi's medical facilities.

4: Immigration irrespective of the place of origin

This will also measure how much Nairobi's technological advancement has succeeded in reducing transfered morbidity. Secondly this variable and migration from high mortality regions can be used to determine mortality levels that are typical of Nairobi experience.

5. Marital status:

Almost all cultures of the world recognize four marital statuses and have highly elaborate description of appropriate behaviour for persons in each status: single (never-married) married, widowed and divorced. Each status has deep religious and legal as well as general social significances. It is assumed here that people who are married enjoy a higher level of socio economic status and besides socio-economic level, such partially independent factors as temperament, motivation and pleasures from the person's social group. In the present study these factors are not measured as such, but one of the marital statuses (divorce) calculated from 1979 census has been considered as an indicator of marital instability. A higher marital instability as measured by percent divorced is expected to have an inverse relationship with life expectancy and a a positive relationship with probability of dying.

6. The dependency ratio:

Dependency ratio statistics measures the impact of age composition on the livelihood activity of the population. It is assumed that the age group 20-64 years is independent and that youth under 20 and older persons aged 65 years and over are the dependent segment. A rough measure of the dependency load that the productive population must bear is the ratio of the population under 20 and 65 and over to the population 20 to 64 multiplied by 100:

$$\text{dependency ratio} = \frac{\text{Pop. under 20yrs + 65 Yrs and over}}{\text{Population 20 years to 64 Yrs.}} \times 100$$

The ratio purports to measure how many dependants each 100 persons in the productive years must support and it is also intended to measure fertility levels, since the more the number of people less than 20 years in a region corresponds to high child woman ratio which is a measure of fertility. This variable is also calculated from the 1979 Kenya census.

7. Medical technology

In this study medical facilities have been considered to be readily available to anybody who is able and aware of their existence. The assumption is based on the following:

a) The transport system seems to be efficient and available to anybody who may seek treatment at various private hospitals and even at the National Hospital (Kenyatta).

b) In each ward there is at least a clinic which treats freely although there may be differences in quality among the various hospital clinics.

The study assumes that there are differences in terms of access to medical facilities because of differences in income and lack of awareness amongst the population of Nairobi. In this study income and awareness will be measured in terms of illiteracy levels. This is based on the assumption that to join the modern employment sector one must have attained a certain level of education.

Given above is a sketch of some macro level factors which should be important determinants of differential mortality rates in the area under study. But we regret not to have considered key variables in this type of study, like availability of water, sewage facilities, toilet and many other sanitary indicators. Lack of this type of data is a limitation to attaining the strength of analysis which was originally intended. Although this was a limitation the list of the variables outlined above is extensive enough to indicate the pattern of mortality variation that exists in Nairobi.

1:6 Summary of Chapters

The first part of Chapter 1 is devoted to the presentation of the relevant theoretical frameworks for mortality analysis. After a general look at the major socio-economic theories of mortality, special attention is focused on the selected mortality predictors.

Chapter 2 on statistical methodology is meant to lay a basis for the fourth chapter which deals with statistical analysis of the interrelationship between mortality and the independent variables.

Chapter 3 examines the quality of the census data, the importance of which cannot be over-emphasized. Particular attention was addressed to arriving at refined and plausible estimates. Chapter 3 also includes discussion on the variations of the levels of mortality among the wards.

Chapter 4 is the analysis on the role of socio-economic and demographic variables in determining child mortality differentials.

Finally conclusions and recommendations based on the findings from the study are given in Chapter 5.

In the next chapter an attempt is made to outline the methodology to be used in analysing the data in this study.

CHAPTER TWO

MATERIALS AND METHODS

2:1 Introduction

The analysis is confined to the period 1978-79 which is conveniently close to the 1979 census. A period of this length is necessary to this kind of study, for socio-economic and even demographic variables have a tendency of changing over time. So if socio-economic data far away from the period considered in estimating mortality levels is included in the analysis, it may not show the true relationship.

Most studies and surveys carried out in Nairobi have been based at ward level. Therefore it is necessary to confine the analysis to the wards for this is the smallest unit for which we have socio-economic and demographic information. Some wards have a considerable range of socio-economic conditions within their boundaries, but the majority are more or less homogeneous. In most cases, the population in each ward (1979) ranged in size from 13,544 (Lumumba Ward) to 23,818 (Uhuru Ward), although there are extremes. For example 69,691 people live in Mathare Valley ward and 7,565 in Waithaka. The statement of levels of illiteracy permitted the formation of social class groupings.

In any study using census data it is important to be aware of the limitations of the information under examination; conclusions are no more accurate than the material on which they are based. The recognized limitation of mortality levels concerning accuracy of establishing genuine levels by the use of various techniques have been studied in another chapter. These limitations were minimised by testing all the possible techniques and using only the one giving the most plausible results. However in some wards the mortality experience by age was not consistent in any method. By consistency here we mean that the expected pattern of mortality experience which is usually supposed to increase monotonically and gradually was contradicted. Because of this persistency in error in some wards, we were forced to graduate the l_x from the basic Brass method using the Coale and Demeny North life table series - to arrive at more acceptable results - this is shown in the third chapter.

We have already hypothesised, in the conceptual model, that:

(1) Mortality differentials (infant and child mortality) between high and low income groups in Nairobi will be found, and that the relationship will be inverse.

(2) That mortality differentials are influenced by the distribution of the following:

(a) 7+ years and 9+ years of education attained by females and males respectively should have an inverse relationship with mortality levels (probability of dying)

(b) Zero years of schooling should have a positive relationship with mortality levels

(c) Dependence ratio should have a positive relationship

(d) Density per hectare should have a positive relationship

(e) Marital status (divorced) should have a positive relationship

(f) Migration should have a positive relationship

(3) Access to health or rather medical facilities is expected to have a negative relationship with mortality levels.

Specifically, in all these hypotheses we wish to test the proposition that high or low mortality for any particular socio-economic class is a function of the characteristics of that social class.

2:2 Methods of analysis

This section of the chapter concentrates on the methods used in the statistical analysis in order to draw conclusions about the sample data. It discusses the quantitative techniques used in this analysis.

In this study only parametric tests are used in analysing the data. There was little need to use non-parametric tests because our data assume normality which is not assumed in non-parametric tests. Parametric tests mainly assume certain conditions in the population and are used only when those assumptions are met. This type of test was selected because it is important in making valid inferences about the studied population. Of this test the Regression Model is the most suitable for analysing the present data. Before one uses the model it is of great importance to test whether to apply the linear or the curvelinear regression model depending on the nature of the data. This is normally done by the use of scattergrams. Scattergrams also show an immediate indication of the relevance of the hypotheses - to be tested.

2.3 Scattergram

A scattergram is obtained by plotting values of the dependent and independent variables on a graph. By convention, the independent variable forms the horizontal and the dependent the vertical axis. After plotting the pairs the general trend can easily be seen. This was done for all the variables before the decision to use the linear regression model was arrived at.

2:4 Regression Model

In this study, the regression model will be used to analyse the data. In a simple regression model it is assumed that the variability in a dependent variable is accounted for partly by a single explanatory variable and partly by a disturbance or error term that might result from the data or partly by the effect of unconsidered variables. So, in this study a simple regression model will be used to predict a dependent variable (mortality) from only one independent variable while other variables are held constant.

In formula form, it amounts to:

$$Y = a + bx + e$$

where Y = dependent variable

a = intercept

b = slope

x = independent variable

e = distribution or error term

The two parameters of the regression equation a and b, indicate the form of the relationship between y and x but say nothing about the accuracy of the estimates of Y that are given by the regression line. For this we use an associated parameter, the correlation-coefficient - it actually measures the degree of association between the variables. Correlation coefficient symbolised by 'r', relates the variance in the dependent variable Y to the reduction in that variance when the independent variable, x, is used to estimate values of Y. This coefficient is of paramount importance and therefore found necessary to be used in this study.

To arrive at this coefficient there are a few steps one undergoes:-

1) Find the ratio between the explained or reduced variance and the original variance

Explained variance = original variance - Residual r. The original variance is known as the coefficient of determination.

2) Calculate the square root of the ratio found in (1).

The square root found in step (2) is actually the correlation coefficient of y on x.

Up to this point it can be realised that the simple linear regression model involves only one variable acting on the dependent variable, but in most demographic studies more than one variable is involved. When this is the case the simple linear regression model is found insufficient to handle a variety of variables. Usually a group of interrelated variables have to be considered in order to explain fully the variability in the dependent variable. This calls for the use of a multiple regression model which attempts to explain or predict a dependent variable from many independent variables.

$$Y = a + b_1X_1 + b_2X_2 + \ldots. + b_xX_x + e$$

where Y = dependent variable

a = intercept

b = slope

X_1, X_2, X_x = independent variables

e = error term

The aim of the regression model is to select a line that best fits through a scatter of points, to provide the best description of the trend in that scatter and the best set of estimates of Y_i from X_i. The correlation analysis measures the goodness of fit of this straight line to the distribution of points.

Nevertheless, the validity of the regression model lies on the fulfilment of several assumptions namely:-

1. Regression analysis fits a straight line trend through a scatter of data points and correlation analysis tests for the goodness of fit of this line. Clearly if the trend cannot be repeated by a straight line, regression analysis will not portray it accurately. But in cases when it is not linear it can be made linear by transforming the data by the use of logarithm.
2. Normality - it is widely assumed that use of the linear regression model requires that the variables have a normal distribution. In fact the requirement is not that the raw data be normally distributed, it is that the conditional distribution of the residuals are normal. The conditional distributions are the values of $(Y_1 - Y_i)$ for every value of X. If these conditional distributions are normal then it is almost certain that the distributions of Y and of X - known as the marginal distributions are also normal, but the converse is not necessarily the case. Thus although many authors test to see their data are normally distributed (see for example

Hart and Salisbury, 1965), they were not inquiring as to whether a necessary prerequisite for normal conditional distributions exist. Of course, one rarely if ever has enough values of 'Y' for every value of 'X' to see if there is a normal conditional distribution, the theory is based on an ideal of very large samples.

3) The error term 'e' is uncorrelated with the independent variable(x) X. This means that there is no systematic association between positive or negative disturbances of high or low values of the independent variable(s).

4) Homoscadasticity, which means that for each independent variable, there is a conditional distribution for the values of the dependent variable and that this distribution is constant all over the linear relationship.

5) The independent variables should not be strongly interrelated.

6) The observations must be at least 20 or more. This is in order to allow for a large number of degrees of freedom in testing the statistical significance of each independent variable.

7) The data used must be in interval scale.

However with all these assumptions the multiple regression has practical problems which the researcher should expect.

The following are some of the multiple regression problems to be expected:

1) There is a problem of multicollinearity when we use many explanatory variables as in this study. Multicollinearity arises when 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.

2) Using the ordinary least square method to estimate parameters, the linear regression model has the following draw-backs:

   a) It can yield probabilities outside the accepted 0-1 interval

   b) The time probability relationship is most likely to be S-shaped than linear, approaching the probability values of zero and one asymptotically.

3) Another problem and possibly the most serious problem in most statistical analysis is the lack of reliability of data. The degree of sophistication of this statistics 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 statistical results from the present study.

After the final regression model it is necessary and statistically in order to check how much the considered variables predict the variability in the depended variable. The procedure of doing that is referred to as geographical autocorrelation.

2:5 <u>The geographical auto-correlation:</u>

When all of the observations do not lie on a straight line, the correlation coefficient indicates the overall fit of the regression line to the scatter of points. It does not indicate either the success of the equation at estimating any particular observation. To obtain the level of success across the cases considered we look at the residuals from the regression.

On the assumption that $r_{y_x} = 1.0$, we can estimate the values of Y_i by substituting the relevant values of X_i in the regression equation. From this we can get the residuals by ward. These are plotted on a map and the structure portrayed checked. This may put us on the road toward formulating new hypotheses. The major concern here is to examine whether variations in levels of prediction have any pattern. Those wards poorly predicted may have certain common characteristics.

In this chapter the methodology to be used in the analysis was discussed. To select the most suitable methods a number of available methods of data analysis were examined and the ones considered were found to be the best suited to the topic under study. The next chapter discusses the data and the results obtained from this methodology.

CHAPTER 3

ESTIMATES OF MORTALITY LEVELS, NAIROBI WARDS BASED ON 1979 CENSUS

3:1 Introduction

In this chapter an attempt is made to look at differentials in child mortality by ward.

Mortality during the early years of life constitutes a large fraction - sometimes, majority - of all deaths in developing countries.[1/] Infants and very young children are delicate and more sensitive to the effects of climate, food or sanitary conditions and to all other pressures of life which nature can exert on man. This gives to childhood mortality statistics a considerable descriptive value. In addition when reasonably accurate they can provide insight into a population's demographic characteristics by facilitating the analysis and understanding of existing fertility and nuptiality patterns. Moreover, childhood mortallty statistics are useful as a sensitive index of a nation's health conditions and as a guide for the structuring of public health programmes. "Yet, childhood mortality levels are typically known only approximately if at all, in developing nations".[2/]

1/ J.M. Sullivan, "Estimation of probability of dying in early childhood". Population Studies, Volume 26, No. 1, pp. 79 [1979].

2/ Op. cit. footnote 1.

In general, most of the data on infant and child mortality (as an overall mortality) in developing countries are limtied and defective, particularly so, due to a scarcity of reliable data. Deaths are registered in only a few countries and in most of these with low coverage. Therefore mortality levels must be computed or estimated from survey and census data. These sources usually provide data on the age and sex composition of a population and of vital events during the past calendar year (reference period data) or during the life-time of the respondent (retrospective data). Current data or reliable reference period data are, of course, an appropriate source of statistics. However, for reasons discussed in the literature the accuracy of data obtained in a single survey or census in a developing country is often questionable. Age misreporting, under enumeration at certain ages and misinterpretation of the duration of the reference period are principal causes of inaccurate census data. In most cases current data on mortality have been found to be deflated. This indicates that they have included many deaths which actually occurred in a period longer than 12 months. Current data on mortality were therefore dropped in the present analysis as they were found to be inaccurate. Instead, data on children surviving among those ever born are used as a better source of estimates. For a number of reasons, for example, recall lapse, the proportions surviving to ages 2, 3 and 5 have been selected as the most suitable for studying child mortality. A technique for converting these retrospective mortality data to more precise mortality measures has been developed by William Brass (Demography of Tropical Africa, 1968). Essentially, the technique provides estimates of the probability of dying between birth and various exact childhood ages. Since the errors often found in the reference period severely limit their usefulness as a source of childhood mortality data, the Brass technique, which relies on retrospective data, is of considerable value. "Indeed, it is the only procedure which will provide relatively accurate estimates of childhood mortality conditions in many populations of the world today".[1/] Brass, Sullivan and Trussell came up with models of mortality estimation claimed to be better. Therefore, the three methods (Brass's, Sullivan's and Trussell's) which deal with errors in the African data, are applied in this chapter in an attempt to arrive at plausible estimates of child mortality for different wards in Nairobi. As the methods are applied special attention will be paid to $_2q_o$ (proportion of infants dying by age 2). $_2q_o$ is thought to be the best estimate as it is derived from retrospective reports of children dead to mothers 20-24 years of age whose experience is most recent

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1/ J.M. Sullivan, "Estimation of probability of dying in early childhood", Population Studies, Volume 26, No. 18, pp. 80, [1979].

and reliable (numbers for mothers aged 15-19 are too small). Secondly, the relationship to death rates at higher ages is more consistent from population to population for mortality under 2 years than under 1 year.[1/]

In the following section, Brass's Basic method for estimating child mortality is applied to the Nairobi 1979 census data taken at ward level.

3:2 Brass Basic Method

Brass derived a method that converts the proportions of dead children born of women in a particular age group, which is essentially the women's total experience, into life table $q_{(i)}$ values.

He assumed that the fertility of women at age x bearing a child can be represented by a constant schedule in recent years. The other assumption he made is that of uniform age distribution of women within each five-year age group. The proportion of children dead of those born to women in a particular age group depends on the age distribution of the children and the mortality pattern of the population. He established that the correlation between proportions surviving among children ever born to women of various ages and childhood

1/ Brass, William (1975). Methods for Estimating Fertility and Mortality from Limited and Defective Data; pp.349.

mortality rates is modified by the shape of the age pattern of fertility schedule, if child bearing begins at very young ages, the children born to each age group of mothers are exposed to the risk of death for a longer period than average time and thus the proportions surviving among children ever born to women of each age group underestimate the proportion surviving to the related birth days. The opposite is true when childbearing begins relatively late in women's lives.

To correct for these variations in age at entry into childbearing, Brass has constructed a set of correction factors to modify the estimates of mortality and survivorship. For younger women, the index of age at entry into childbearing is the ratio of children ever born to women aged 15-19 to children ever born to women 20-24 (P_1/P_2). For women at older ages the mean ($\bar{m}$)or median ($\bar{m}'$) age at fertility is used. Correction factors corresponding to values of P_1/P_2, $\bar{m}$, intermediate between the Brass multipliers can be obtained through linear interpolation.

The proportion of children dead among children ever born to women in each age group are then multiplied by these correction factors to obtain estimates of q_x.

Using the Brass Method results (see Table 1) were obtained from Nairobi-wards. The table shows $_xq_o$, l_x from the Brass Basic Method and the number of women in the age group 20-24.

TABLE 1 ESTIMATES OF PROBABILITIES OF DYING IN EARLY CHILDHOOD $_xq_o$ AND 1_x(ii)
NAIROBI WARDS BASED ON 1979 CENSUS

Ward	BRASS			1_x from Brass Basic Method			No. of women in age group 20-24
	($_2q_o$)	($_3q_o$)	($_5q_c$)	(1_2)	(1_3)	(1_5)	
1 KARIOBANGI	0.102	0.116	0.132	898	884	868	3,097
2 DANDORA	0.097	0.086	0.115	903	914	885	1,841
3 EASTLEIGH	0.074	0.066	0.077	926	934	923	3,994
4 MAKADARA	0.088	0.097	0.104	912	903	896	9,854
5 MATHARE	0.099	0.115	0.126	901	885	874	4,434
6 EMBAKASI	0.086	0.101	0.119	914	899	881	655
7 KAWANGWARE	0.096	0.108	0.140	904	892	860	1,519
8 KIBERA/WOOD	0.111	0.120	0.122	889	880	878	4,545
9 PUMWANI	0.108	0.110	0.134	892	890	866	757
10 PANGANI	0.055	0.048	0.051	945	952	949	1,285
11 HARAMBEE	0.053	0.058	0.066	947	942	934	1,090
12 NRB SOUTH WEST	0.054	0.054	0.057	946	946	943	1,891
13 UHURU	0.042	0.056	0.057	958	944	943	1,540
14 PARKLANDS	0.068	0.053	0.063	932	947	937	1,616
15 GOLF-COURSE	0.085	0.067	0.068	915	933	932	1,401
16 LILIMANI	0.072	0.072	0.067	928	927	933	2,780
17 KARURA	0.104	0.146	0.135	896	854	865	483
18 KAREN/LANGATA	0.098	0.093	0.096	902	907	904	583
19 MUJUINI	0.048	0.049	0.064	952	951	936	291
20 WAITHAKA	0.041	0.046	0.053	959	953	947	390
21 UTHIRU	0.073	0.065	0.080	927	935	920	419
22 LUMUMBA	0.079	0.058	0.073	921	942	927	795
23 KANGEMI	0.075	0.080	0.105	925	920	895	1,038
24 NGARA WEST	0.049	0.067	0.052	951	933	948	715
25 NGARA EAST	0.064	0.072	0.072	936	928	928	1,269
26 MARINGO	0.069	0.081	0.082	931	919	918	722
27 INDUST. AREA	0.109	0.126	0.087	891	874	913	375
28 CITY CENTRE	0.086	0.099	0.107	914	901	893	1,115
29 N R B CENTRAL	0.082	0.066	0.095	918	934	905	571
30 R Y/KAHAWA	0.087	0.085	0.087	913	915	913	1,559
31 SPRING VALLEY	0.088	0.078	0.071	912	922	929	967
32 MUNGUMONI	0.088	0.064	0.090	912	936	910	926
33 RUARAKA KASARANI	0.152	0.157	0.182	848	843	818	1,851
34 SHAURI MOYO	0.089	0.098	0.138	911	902	862	1,010
35 BAHATI	0.066	0.071	0.092	934	929	908	539
36 MBOTELA	0.083	0.115	0.114	917	885	886	816
37 MAISHA MAKONGENI	0.127	0.125	0.133	873	875	867	965
38 KALOLENI	0.082	0.104	0.141	918	896	859	269
39 RIRUTA SATELITE	0.068	0.066	0.096	932	934	904	1,287
40 ZIWANI KARIOKOR	0.073	0.093	0.106	927	907	894	451

On checking the method's consistency, we found that Brass is reasonably consistent in 22 out of 40 cases considered in the study. In Table 1 it can be seen that the method is not consistent in Dandora, Eastleigh, Parklands, Colf-Course, Kilimani, etc. In the inconsistent cases, instead of the probability of dying increasing monotomically from ${}_2q_o$ upwards, the opposite is true. Any distortion of this kind where

$${}_2q_o > {}_3q_o < {}_5q_o \quad \text{or} \quad {}_2q_o < {}_3q_o > {}_5q_o$$ is in itself inconsistent.

These inconsistencies put the author in a very doubtful position on the rationality of leaving out 18 cases which were originally intended to be studied. This kind of situation necessitates a search for better estimates. Sullivan argued that instead of multiplying the proportions of children who had died of women in standard age groups by a factor which depended on the shape of the fertility function to yield $q_{(x)}$ value, it should be done by multiplying the proportions by the actual fertility pattern. He continued to argue that instead of the polynomial employed by Brass to generate fertility schedule to develop the Brass Model, multiplying factors based on linear regression yielded better results than the table of factors developed by Brass.[1/]

1/ T. James Trussell, A re-estimation of the multiplying factors for the Brass Technique for determining childhood survivorship rates. Population Studies, pp. 97. Vol 29. No 1 [1975].

With this claim mentioned above, the author is motivated to make an attempt to estimate Nairobi ward mortality using Sullivan Model. The attempt is made in the following sub-section.

3:3 Sullivan's Method for Estimating Child Mortality

Sullivan's analysis makes use of the relationship between the proportions of deaths of children ever born to women in each age structure of fertility. He maintains that there is a close relationship between $P_2/\hat{P}_3$ (where P_2 is the average parity of women aged 20-24 years and P_3 that of women aged 25-29), on the one hand, and the ratios ${}_2q_o$, ${}_3q_o$ and ${}_5q_o$ divided by the proportion dead of children ever born to women in appropriate age groups on the other. Using regression equations the proportions dead (D_2) are converted into probabilities of dying (${}_xq_o$) and the proportions surviving (l_x) are arrived at by subtracting ${}_xq_o$ from 1000.

The conversion equations for the North family are:1/

North

$${}_2q_o/D_2 = 1.30 - .63\ (P_2/P_3)$$

$${}_3q_o/D_3 = 1.17 - .50\ (P_2/P_3)$$

$${}_5q_o/D_4 = 1.15 - .43\ (P_2/P_3)$$

The estimates of ${}_2q_o$, ${}_3q_o$ and ${}_5q_o$ arrived at by the method are shown in Table 2 overleaf. It can be seen that the values in ${}_2q_o$ for Brass are similar or more or less

1/ J.M. Sullivan, "Estimation of probability of dying in early childhood", Population Studies, Volume 26, No. 1, pp. 79-97.[1979].

TABLE 2 ESTIMATES OF PROBABILITIES OF DYING IN EARLY CHILDHOOD
NAIROBI WARDS BASED ON 1979 CENSUS

Ward	SULLIVAN		
	$_2q_0$	$_3q_0$	$_5q_0$
1. KARIOBANGI	0.101	0.108	0.125
2. DANDORA	0.097	0.081	0.109
3. EASTLEIGH	0.072	0.062	0.072
4. MAKADARA	0.086	0.090	0.098
5. EMBAKASI	0.083	0.091	0.109
6. MATHARE	0.111	0.116	0.126
7. KAWANGWARE	0.095	0.100	0.132
8. KIBERA	0.108	0.111	0.113
9. PUMWANI	0.111	0.126	0.157
10. PANGANI	0.054	0.046	0.049
11. HARAMBEE	0.054	0.057	0.066
12. NAIROBI SOUTH-WEST	0.055	0.052	0.056
13. UHURU	0.043	0.055	0.056
14. PARKLANDS	0.067	0.055	0.061
15. GOLF-COURSE	0.090	0.067	0.068
16. KILIMANI	0.073	0.070	0.063
17. KARURA	0.139	0.121	0.136
18. KAREN/LANGATA	0.095	0.086	0.089
19. MUTUINI	0.046	0.045	0.060
20. WAITHAKA	0.039	0.042	0.049
21. UTHIRU	0.071	0.061	0.076
22. LUMUMBA	0.081	0.056	0.071
23. KANGEMI	0.072	0.073	0.098
24. NGARA WEST	0.048	0.063	0.049
25. NGARA EAST	0.068	0.069	0.054
26. MARINGO	0.074	0.076	0.077
27. INDUSTRIAL AREA	0.114	0.124	0.086
28. CITY CENTRE	0.080	0.089	0.099
29. NAIROBI CENTRAL	0.081	0.062	0.090
30. ROYSAMBU/KAHAWA	0.084	0.076	0.081
31. SPRING VALLEY	0.085	0.072	0.067
32. MUNGUMONI	0.089	0.061	0.087
33. RUARAKA/KASARANI	0.149	0.145	0.170
34. SHAURI MOYO/MUTHURWA	0.086	0.089	0.129
35. BAHATI	0.068	0.069	0.089
36. MBOTELA	0.081	0.109	0.109
37. MAISHA MAKONGENI	0.175	0.117	0.125
38. KALOLENI	0.085	0.138	0.103
39. RIRUTA SATELITE	0.067	0.061	0.089
40. ZIWANI/KARIOKOR	0.074	0.091	0.104

similar to $_2q_o$ of Sullivan. The $_3q_o$ have a greater divergence, this divergence is possible because of the following:

1) P_2/P_3: The index of the age structure of fertility which Sullivan uses reflects the fertility of women 30 years and below, while P_1/P_2 (one of the indices Brass uses to choose the multipliers) reflects the fertility experience of women less than 25 years.

2) The Brass fertility function particularly the procedure of sliding that function along the age axis may not simulate the variability of empirical fertility schedules as completely as does the model developed by Sullivan.[1/]

According to the results arrived at by the Sullivan method only 17 out of 40 cases are consistent. Others show a lot of fluctuations and distortions (see Table 2). If we take this as a measure of goodness of fit of any method to the data, it may be concluded that Sullivan's method does not fit the data of 23 wards as well as Brass's basic method.

Although Brass does better for most cases (therefore dismissing the early allegation that Sullivan's method is better than Brass's in this particular data), both results

1/ J.M. Sullivan, "Estimation of probability of dying in early childhood", Population Studies, Volume 26, No. 1, pp. 79-97, [1972].

seem to be inflated - looking at cases like Karen-Langata, Spring Valley, Pumwani, etc., the results appear implausible. Therefore Trussell's method which re-examined Sullivan's method of sliding the fertility schedule up and down the age axis is applied in the Nairobi case. Trussell argues that such sliding does not replicate later or earlier patterns of fertility. As a consequence of these findings it was decided that the experimental test of the Brass Model performed by Sullivan should be run again. The new estimate of multiplying factors developed after the run are significantly superior to those given by either Brass or Sullivan, but of course are based on their pioneering work.[1/]

For purposes of deriving better estimates in this study, the next sub-section is devoted to using Trussell's method which is a more recent development.

3:4 Trussell's method of mortality estimation

Trussell's method has been tested, and evolved. These schedules have shown to represent many empirical situations quite adequately. The set shows that the age patterns of fertility are different when the age at which fertility starts is early rather than late. That is the linear

1/ T.J. Trussell, "A re-estimation of multiplying factors for Brass technique of determining childhood survivorship rates", Population Studies, Volume 29, pp. 97, [1975].

translation of fertility schedules up and down the age axis without altering the relative magnitude of age-specific rates implied by the Brass procedure and used by Sullivan does not adequately replicate earlier or later patterns of fertility.

The multipliers, $K_i = A(P_1/P_2) + B(P_2/P_3) + C\log_e(P_1/P_2) + D\log_e(P_2/P_3) + E$ computed by Trussell are now considered most suitable. A, B, C, D and E are coefficients that depend on mortality patterns believed to hold, $q_{(1)}/D_{(1)} = K_{(1)}$.[1/]

The conversion equation for the north family:[2/]

North

$$K_2 = (0.3615)(P_1/P_2) + (-0.0509)(P_2/P_3) + (-0.0363)\text{Log}_e P_1/P_2 + (-0.0645)\text{Log}_e P_2/P_3 + 0.9674$$

$$K_3 = (-0.0508)(P_1/P_2) + (-0.1467)(P_2/P_3) + (0.0109)\text{Log}_e(P_1/P_2) + (-0.1565)\text{Log}_e(P_2/P_3) + 0.9281$$

$$K_4 = (0.0666)(P_1/P_2) + (-0.1683)(P_2/P_3) + 0.03\text{Log}_e P_1/P_2 + (-0.1739)\text{Log}_e P_2/P_3 + 0.9623$$

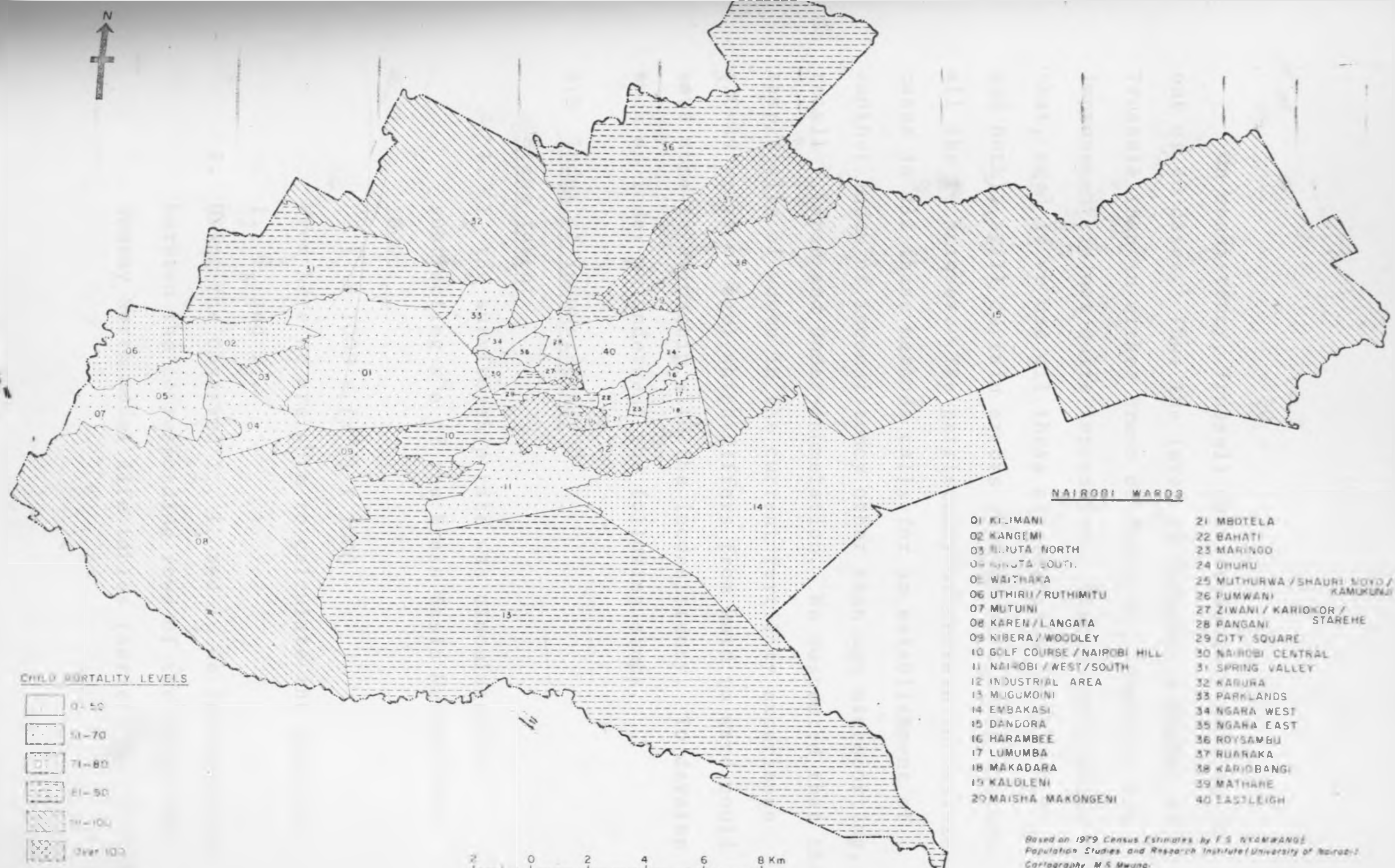
By applying the Trussell's method on the Nairobi data, the following results (see Table 3) were obtained. (Table 3 overleaf and map on child mortality on the next page).

1/ R.A. Henin, "A Sample of methods of estimating basic demographic indices from incomplete data". A series of lectures prepared for graduate students, University of Nairobi, pp. 20, [1980]

2/ T.J. Trussell, "A re-estimation of multiplying factors for the Brass technique for determining childhood survivorship rates". Population Studies, Vol. 29, pp. 102. [1975].

TABLE 3 ESTIMATES OF PROBABILITIES OF DYING IN EARLY CHILDHOOD
$_xq_o$ e L_x NAIROBI WARDS BASED ON 1979 CENSUS

Ward	TRUSSELL		
	$_2q_o$	$_3q_o$	$_5q_o$
1. KARIOBANGI	0.097	0.109	0.132
2. DANDORA	0.093	0.082	0.113
3. EASTLEIGH	0.069	0.065	0.078
4. MAKADARA	0.079	0.092	0.100
5. EMBAKASI	0.080	0.096	0.116
6. MATHARE	0.099	0.118	0.130
7. KAWANGWARE	0.091	0.102	0.136
8. KIBERA/WOODLEY	0.113	0.112	0.121
9. PUMWANI	0.104	0.128	0.164
10. PANGANI	0.053	0.049	0.044
11. HARAMBEE	0.053	0.055	0.067
12. NAIROBI SOUTH WEST	0.055	0.056	0.061
13. UHURU	0.036	0.056	0.061
14. PARKLANDS	0.066	0.056	0.062
15. GOLF-COURSE	0.087	0.066	0.077
16. KILIMANI	0.067	0.071	0.067
17. KARURA	0.099	0.138	0.136
18. KAREN/LANGATA	0.094	0.088	0.092
19. MUTUNI	0.044	0.045	0.060
20. WAITHAKA	0.039	0.043	0.056
21. UTHIRU	0.072	0.062	0.077
22. LUMUMBA	0.076	0.056	0.073
23. KANGEMI	0.072	0.074	0.101
24. NGARA WEST	0.049	0.064	0.065
25. NGARA EAST	0.063	0.068	0.068
26. MARINGO	0.068	0.070	0.079
27. INDUSTRIAL AREA	0.108	0.126	0.090
28. CITY CENTRE	0.082	0.093	0.101
29. NAIROBI CENTRAL	0.079	0.063	0.093
30. ROYSAMBU/KAHAWA	0.084	0.079	0.083
31. SPRING VALLEY	0.085	0.073	0.068
32. MUNGUMONI	0.085	0.081	0.089
33. RUARAKA/KASSARANI	0.143	0.148	0.177
34. SHAURI MOYO/MUTURWA	0.085	0.092	0.133
35. BAHATI	0.070	0.070	0.093
36. MNOTELA	0.080	0.071	0.112
37. MAISHA/MAKONGENI	0.126	0.138	0.154
38. RIRUTA SATELITE	0.065	0.056	0.093
39. KALOLENI	0.082	0.116	0.165
40. ZIWANI/KARIOKOR	0.073	0.092	0.129


N
CHILD MORTALITY LEVELS
0-50
51-70
71-80
81-90
91-100
Over 100
2 0 2 4 6 8 Km
NAIROBI WARDS
01 KILIMANI
02 KANGEMI
03 RIRUTA NORTH
04 RIRUTA SOUTH
05 WAITHAKA
06 UTHIRU / RUTHIMITU
07 MUTUINI
08 KAREN / LANGATA
09 KIBERA / WOODLEY
10 GOLF COURSE / NAIROBI HILL
11 NAIROBI / WEST / SOUTH
12 INDUSTRIAL AREA
13 MUGUMOINI
14 EMBAKASI
15 DANDORA
16 HARAMBEE
17 LUMUMBA
18 MAKADARA
19 KALOLENI
20 MAISHA MAKONGENI
21 MBOTELA
22 BAHATI
23 MARINGO
24 UHURU
25 MUTHURWA / SHAURI MOYO / KAMUKUNJI
26 PUMWANI
27 ZIWANI / KARIOKOR / STAREHE
28 PANGANI
29 CITY SQUARE
30 NAIROBI CENTRAL
31 SPRING VALLEY
32 KARURA
33 PARKLANDS
34 NGARA WEST
35 NGARA EAST
36 ROYSAMBU
37 RUARAKA
38 KARIOBANGI
39 MATHARE
40 EASTLEIGH
Based on 1979 Census Estimates by F.S. NYAMWANGE
Population Studies and Research Institute/University of Nairobi
Cartography M.S. Mwang

On consistency, Trussell does reasonably well in 25 out of 40 cases. Thus the level of fitness is higher in Trussell than in either Brass or Sullivan. However, the improvement is not quite impressive. This clearly shows that, even if we use all these alternatives (P_1/P_2, P_2/P_3 and both), still certain errors seem to be sieving through all the techniques. The persistency of certain inconsistent cases in all these methods calls for an establishment of another index of inconsistency other than age misreporting, recall - lapse and under-enumeration. We suspected that the sample size of women in the current fertility experience (20-49 years of age) which differs from ward to ward could have some relationship with the inconsistency. To develop such an index we underwent the following steps.

3:5 Index of inconsistency

Steps taken:

1. 1_x the survivorship rate was claculated by subtracting $_xq_o$ of the Brass Basic Method from 1000.

   $$1_x = 1000 - (_xq_o) X 1000$$

   From here we are able to calculate the observed 1_2, 1_3 and 1_5.

2. Using the observed 1_2, 1_3 and 1_5 we interpolated between the corresponding rows of the Coale and Demeny North model life tables (series) and arrived

at respective levels of mortality.

3. The mean of the three levels of mortality was then calculated.

4. Using now the mean mortality levels we again interpolated between the rows of the Coale and Demeny North model series to arrive at the expected l_2, l_3 and l_5.

5. The absolute difference between the observed l_2, l_3 and l_5 and the expected l_2, l_3 and l_5 respectively was calculated.

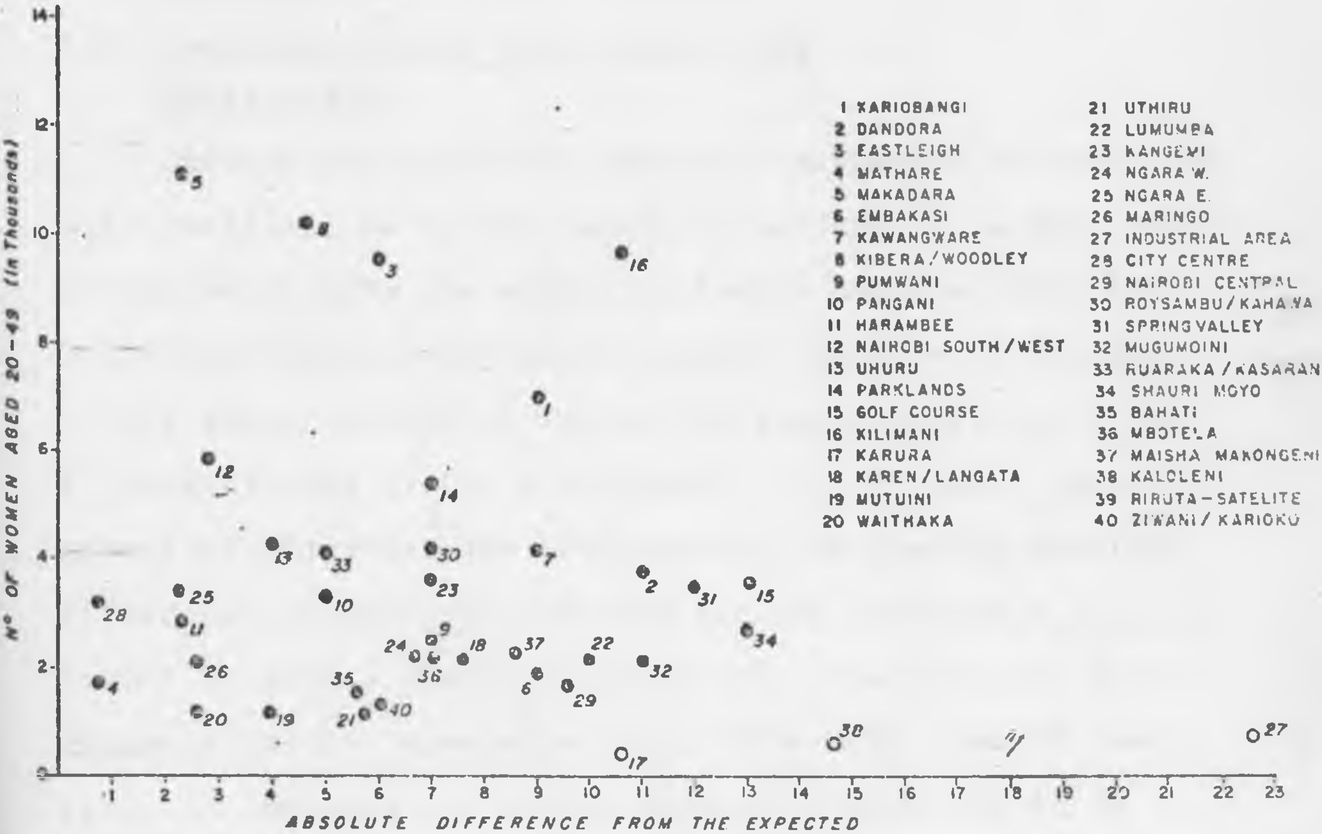
6. The sum of the respective absolute difference was then calculated and the mean also calculated, at the same time.

7. Now the mean of the absolute differences was considered as the level of divergence of the observed from the expected l_x, (s), hence creating an index of inconsistency. Table of the calculation is shown in Appendix 1.

8. Using the absolute differences and their corresponding sample size of women aged 20-49, a graph was constructed as shown overleaf (Graph No. 1).

On close examination it was realised that there was some evidence from the graph that sample size had at least an influence on the degree of inconsistency. It can be seen from the graph that sample sizes which were greater

SAMPLE SIZE AND THE LEVEL OF INCONSISTENCY



than 1000 diverged from the expected by an absolute difference of less than 9. This is not claiming that sample size totally explains the inconsistencies; there could be other variables but sample size has some contributory effect.

3:6 Coale and Demeny North Model life table series

Having tried all the possible techniques to arrive at more realistic mortality rates for Nairobi, as a last resort we agreed to take the mortality levels obtained from the Coale and Demeny North model series. Ours is an average of the three mortality levels corresponding to l_2, l_3 and l_5 respectively (Table 4 overleaf). l_2, l_3 and l_5 are number of survivors for 1000 births. An average absolute difference between the observed and the expected l_2, l_3, l_5, levels is also a number of survivors. The absolute differences in this case were found to be less than 16 (see Table in Appendix 1), except in only 2 cases out of 40 which had absolute differences of 21 and 25 respectively. That means that for l_2, l_3 and l_5 one is on average less than 16 survivors off in 38 out of the 40 wards. That is not very much, considering a radix of 1000 births. This finding justifies the incorporation of all the 40 wards and hence the use of the overall average mortality level as a dependent variable in further regression work. Child mortality levels express the strength of incidence of dying

TABLE 4 LEVELS OF MORTALITY PER WARD

Ward	Level of Mortality	Ward	Level of mortality
1 KARIOBANGI	15.9	21 UTHIRU	18.8
2 DANDORA	17.4	22 LUMUMBA	19.0
3 EASTLEIGH	18.7	23 KANGEMI	17.7
4 MAKADARA	17.1	24 NGARA WEST	20.2
5 MATHARE	16.0	25 NGARA EAST	19.0
6. EMBAKASI	16.7	26. MARINGO	18.3
7. KAWANGWARE	16.5	27 INDUST. AREA	17.2
8. KIBERA/WOODLEY	15.7	28 CITY CENTRE	17.0
9. PUMWANI	16.0	29 NBI CENTRAL	18.0
10. PANGANI	20.4	30 ROYSAMBU	17.7
11. HARAMBEE	19.0	31 SPRING VALLEY	18.3
12. NBI SOUTH & WEST	20.1	32 MUNHUMUNI	18.1
13. UHURU	20.4	33 RUARAKA	13.1
14. PARKLANDS	19.7	34 SHAURI MOYO	16.4
15. GOLF COURSE	18.6	35 BAHATI	18.6
16. KILIMANI	18.9	36 MBOTELA	16.6
17. KARURA	15.1	37 MAISHA MAKONGENI	15.0
18. KAREN/LANGATA	17.2	38 KALOLENI	16.4
19. MUTUINI	20.3	39 RIRUTA SATELITE	18.4
20. WAITHAKA	20.9	40 ZIWANI/KARIOKOR	17.5

before age 5. Table 4 for all Nairobi wards is shown above.

To be certain about our choice a further check on how close the l_2 from the Coale and Demeny North Model series agrees with l_2 from the Brass's African Standard life table may be important. So as a matter of confirmation the following subsection discusses and develops graduated l_2 from the Brass's standard African life tables. The graduated l_2[1/] of child mortality. The graduation is based on l_2, l_3 and l_5, the three survival ratios arrived at by Brass's basic method. The three survivorship ratios transformed into logits from which the corresponding logits of the African standard are subtracted and the mean of the deviations is computed. Then the mean of the deviations is added to the logit of l_2 in the African standard and by anti-logit transformation of the sum a new value of l_2 is produced. But before the method is used in this section a word about the African standard model life table may be useful.

The African standard model life table was developed by Brass after studying data from African surveys. From experience he concluded that survivorship ratios of two life tables are approximately linearly related on a logit scale for various ages.[2/] If one life table with survivorship ratios $l_s(x)$ is taken as a standard, the linear relationship

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1/ W. Brass, et al., op. cit. pp. 351 [1975].

2/ a) W. Brass "Uses of census or survey data for estimation of vital rates". op. cit. pp. 17-22.
b) W. Brass, et al op. cit. pp. 133-135.

$Y_{(x)} = \alpha + \beta y_s(x)$ where $Y_{s(x)}$ and $Y_{(x)}$ are the logits for the standard and any life table respectively with (α) and (β) as two constants. The intercept (α) measures the level of child mortality and the gradient (β) the steepness of the increase of death rates with age. He states that:

> "Greater accuracy can, therefore, be achieved if it is possible to choose a standard which has the same detailed characteristics as mortality configuration of the population which is studied. An "African Standard" life table has been developed based on the experience in the use of the model system for the analysis of mortality records of African communities. In this life table the infant mortality is relatively lower but subsequent childhood mortality higher than in the general standard".1/

The model is designed to describe mortality patterns from childhood up to middle adult years as accurately as possible. In particular, the logit transformation estimate of child survival especially at age 2, and then the selection of some overall estimate of adult mortality.

The procedure of arriving at graduated l_2 is shown in Appendix 2 with Mathare ward as an example. In Table 5 (overleaf) the graduated l_2 values are shown and alongside from the Coale and Demeny North Model series are compared. It can

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1/ W. Brass "Uses of census or survey data for the estimation of vital rates". op. cit. p. 19,[1975].

TABLE 5 ABSOLUTE DIFFERENCES BETWEEN GRADUATED 1_2 BY BRASS AFRICAN STANDARD LIFE TABLES AND 1_2^2 FROM COALE AND DEMENY LIFE TABLES

Ward	1_2(B)	1_2(C & D)	Absolute Difference
1. KARIOBANGI	899	897	3
2. DANDORA	907	917	10
3. EASTLEIGH	979	933	46
4. MAKADARA	927	913	14
5. EMBAKASI	919	906	13
6. MATHARE	905	879	7
7. KAWANGWARE	904	905	1
8. KIBERA/WOODLEY	895	894	1
9. PUMWANI	900	898	2
10. PANGANI	999	952	48
11. HARAMBEE	992	948	44
12. NAIROBI SOUTH WEST	998	949	48
13. UHURU	999	952	48
14. PARKLANDS	985	944	41
15. GOLF COURSE	998	932	66
16. KILIMANI	968	935	33
17. KARURA	888	885	3
18. KAREN/LANGATA	927	914	13
19. MUTUINI	998	951	49
20. WAITHAKA	999	959	41
21. UTHIRU	964	935	29
22. LUMUMBA	969	937	32
23. KANGEMI	941	921	20
24. NGARA WEST	998	950	48
25. NGARA WEST	966	937	29
26. MARINGO	957	929	28
27. INDUSTRIAL AREA	913	912	1
28. CITY CENTRE	931	912	19
29. NAIROBI CENTRAL	951	925	26
30. ROYSAMBU/KAHAWA	938	921	17
31. SPRONG VALLEY	880	930	50
32. MUNGUMONI	944	926	18
33. RUARAKA/KASARANI	853	853	0
34. SHAURI MOYO/MWOHURWA	888	904	18
35. BAHATI	956	932	24
36. MBOTELA	917	906	11
37. MAISHA MAKONGENI	887	884	3
38. RIRUTA SATELITE	959	904	55
39. KALOLENI	911	930	19
40. ZIWANI/KARIOKOR	936	919	17

can be seen that graduated l_2 is terribly inflated, suggesting an error in age misreporting. Women who were supposed to be in the other two neighbouring age groups reported their ages to be 20-24, hence their fertility experience was heaped in this age group. This could be another error creating inconsistency. All in all, at this level we have had a clear knowledge of the data to be studied. In order to reduce measurement error as well as to observe a more or less true picture on ward mortality differentials, results from the Coale and Demeny North Model series are to be used in this analysis. Therefore the average levels of mortality shown in Table 4 are the basis of this study.

3:7 Mortality difference between wards

Based on percent illiteracy by ward we were able to classify wards into social status. With this criteria we plotted a graph, illiteracy against average mortality levels (graph shown overleaf). As hypothesized in Chapter 1 that mortality differentials (child) between high and low income groups will be found and that the relationship will be inverse - this is clearly portrayed in the graph overleaf. The middle class experience a relative low mortality as compared to the low class wards - this confirms the first hypothesis. But in certain wards like Mutuini (19) and Waithaka (20) in low class category experience a mortality level which is lower than that experienced in middle class wards. This creates a lot of suspicion. However, the two wards have a certain commonality. They both fall within the urban fringe, in which case they are wards at the periphery. Being at the periphery or not may be an important variable in determining mortality levels but at this level the present writer cannot give any suggestions for there is no data available to warrant that.

These mortality differences are striking and there is a need to search for determinants, for they could not have happened by chance. To do this, some socio-economic and demographic variables are to be correlated to the dependent variable (mortality levels) - using the already stated regression model. The next chapter actually intends to discuss that.

CHAPTER 4

THE ROLE OF SOCIO-ECONOMIC AND DEMOGRAPHIC VARIABLES IN DETERMINING CHILD MORTALITY DIFFERENTIALS

4:1 Introduction

A "determinant" of mortality can be defined as a variable that would change a population mortality levels if its own value is altered. This definition is broad enough to encompass the proximate biological determinants of mortality (e.g. nutritional intake, exposure to disease) and the socio-economic-cultural factors that operate indirectly through the proximate factors. Some of the socio-economic-cultural factors are themselves arranged hierarchically. Increased levels of education, for example, may alter many other features of a household's living conditions such as knowledge of proper health practices, income levels, sexual balance of power and access to health facilities (Caldwell, 1979).

Many of the determinants of child mortality are properties of the household in which the child is located. This includes levels of household income, adult literacy, health practices among members, sanitary facilities, etc. Other determinants are properties of the "community" of households: organization of health care system, ecological characteristics such as climate, rainfall, presence of disease vectors, distribution of land resources, etc.

Unfortunately, in the census data we were not able to measure the value of many of the main variables that would be of interest. One issue that can be addressed effectively is whether the ward mortality differences identified above are a product of differences in the distribution of household's socio-economic and demographic characteristics among the wards or whether they persist independent of this distribution. But before we address ourselves to the core of the analysis, it pays to show the general pattern of our independent and dependent variables using scattergrams. Scattergrams are intended to give us a general impression of the relationship between independent variables and the dependent variable.

4:1:1 Scattergrams

This subsection will show scattergrams of the dependent variable and those independent variables that were considered in the final regression model. The variables are as follows:-

1) V0002 - Mortality levels per ward
2) V0003 - % immigrants from high mortality areas 1 year before 1979 census
3) V0004 - Total % immigrants per ward 1 year before 1979 census
4) V0005 - % adult illiteracy per ward

5) V0006 - % females 15-49 years of age with 7+ years of schooling

6) V0007 - % males 15-49 years of age with 9+ years of schooling

7) V0008 - Population density per hectare by ward

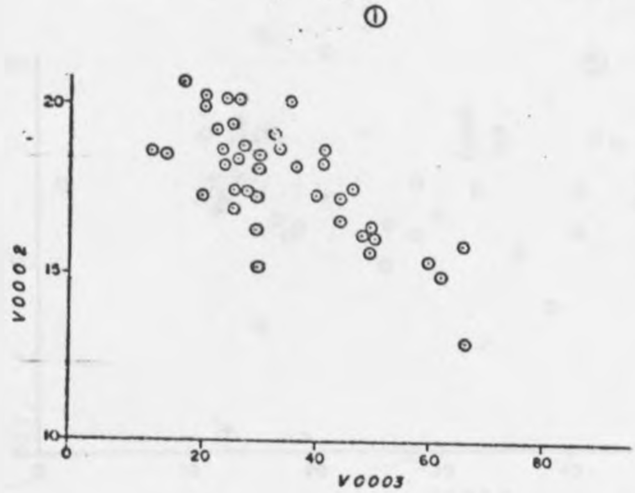
Scattergrams of the above variables are shown below.

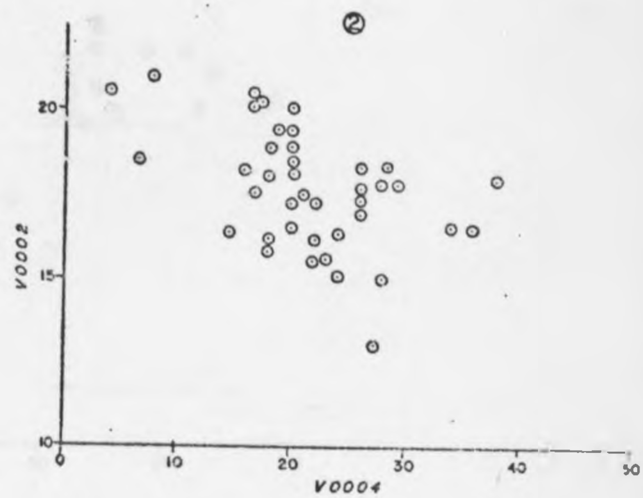
The scattergrams below clearly demonstrate that the variables considered have a linear relationship with the dependent variable. This justifies the use of the linear regression model. In addition, the direction of the relationship agrees with the earlier stated hypotheses. For example, we had hypothesized that migration from high mortality regions will have a negative relationship with levels of mortality (life expectancy - this can be seen in Graph 2 -- scattergram --). Having confirmed this, the following subsections are intended to discuss the results of the multivariate regression model.

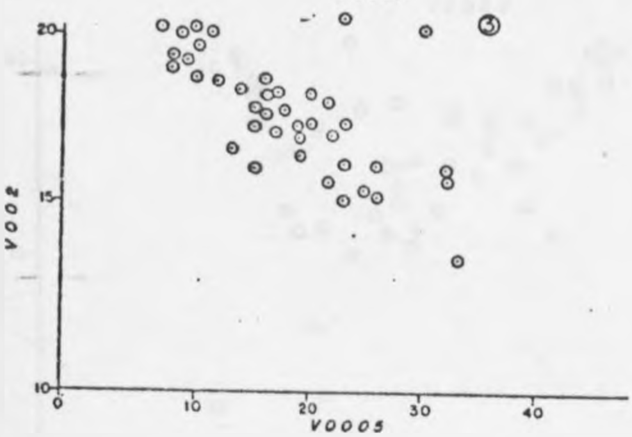
4:2 <u>Results of the Regression Model</u>

In the foregoing chapter it has been shown that mortality differentials exist between wards in Nairobi. These mortality differentials are due to the combined effect of demographic, biological and socio-economic factors. In this chapter it is postulated that some of

SCATTER GRAMS







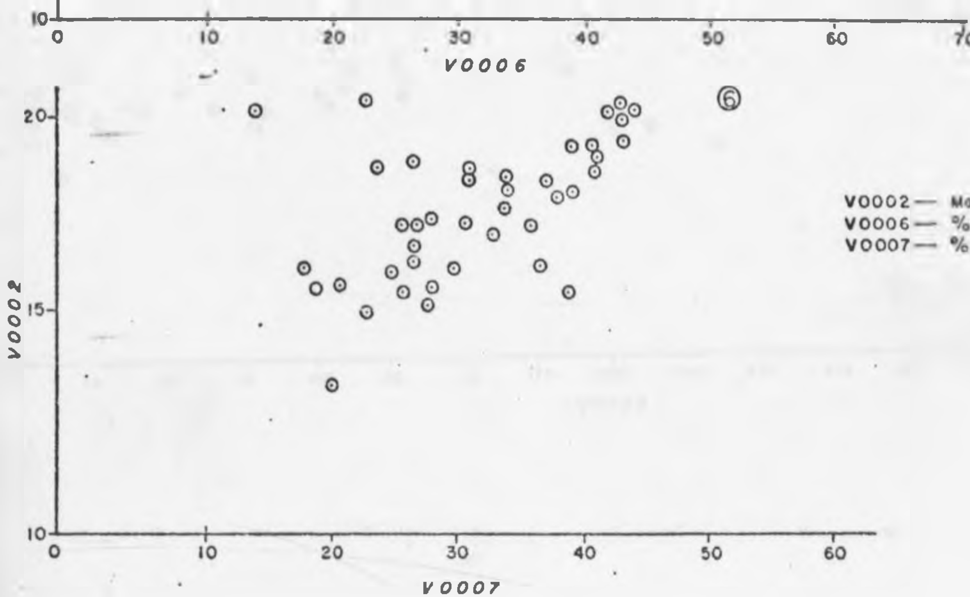
KEY

V0002 — Mortality Levels Per 1000

V0003 — % Migration From High Mortality Areas 1yr Before 1979 Census

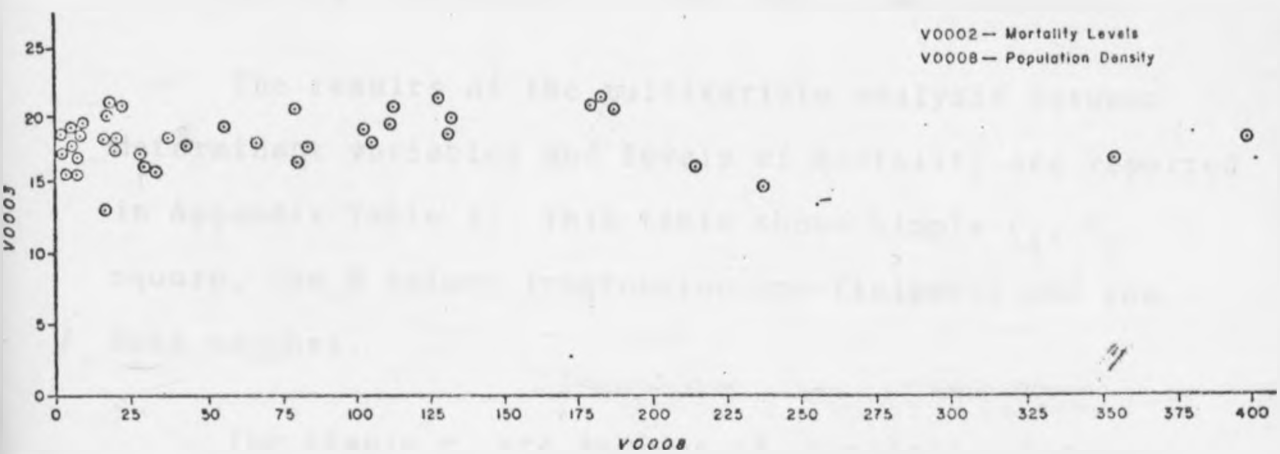
V0004 — Total % Migration Per Ward 1yr Before 1979 Census

V0005 — % Illiterate Per Ward



V0002 — Mortality Levels per 1000
V0006 — % Females 15-49 Yrs With 7+Yrs of SC
V0007 — % Males 15-49 Yrs With 9+Yrs of S

SCATTER GRAMS


V0002 — Mortality Levels
V0008 — Population Density
V0003
V0008
0
5
10
15
20
25
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400

the observed mortality differentials are due to the variant influences that are exerted on mortality by some socio-economic variables found in different wards. Thus socio-economic variables are viewed as having had some independent underlying influences on present mortality differentials.

When the first regression was run, dependence ratio and percent divorced were found to be highly correlated with percent immigrants. To avoid the effect of multi-collinearity, we decided to drop these two variables.

The results of the multivariate analysis between determinant variables and levels of mortality are reported in Appendix Table 3. This table shows simple r_s, R_2 square, the B values (regression coe-ficients) and the Beta weights.

The simple r_s are indices of association between the dependent variable and each of the independent variables. The Beta weights are indices for determining which of the several independent variables has the highest association with the dependent variable, either the Beta weight or the r_s yields partial elasticities of mortality with respect to the independent variables. So that the analyst can hold variables constant and come as near as the population scientists are likely to get to the laboratory conditions needed to identify and isolate the role of single variables and hence of single policies. Thus either can be used to estimate the relative cost-effectiveness of alternative policies. The squares of the multipliers R_s are indices of the proportion of variance explained by each of the selected independent variables.

From the multipliers in Appendix Table 3, it can be inferred that the selected socio-economic, demographic and environmental indicators are good predictors of mortality variations in Nairobi. Since they account for 83.62 (cumulated R_s) of the variation - but this remains to be proven in another section. It further shows that mother's education (7+ years of schooling), father's education (9+ years of schooling) and population density per hectare by ward are not strong indicators of mortality variation in Nairobi. They account for 0.04%, 0.1% and 0.2%, respectively, of the variation. This is a very low contribution indeed. Immigration, and especially immigration from high mortality regions, plus adult illiteracy take the upper hand in explaining the variation. The table shows that these three variables account for 83.1% of the variation. Each variable is now considered individually.

4:2:1 Education

Caldwell (1979) and Preston (1978) have argued that advances in female education may represent a potent and cost-effective means of reducing child mortality. Behm (1976-78) presents abundant information suggesting that maternal education powerfully differentiates among child mortality levels in Latin America and Cochrane (1980) compiled confirmatory evidence from other regions. For Nairobi, three types of educational levels were used (V0005, V0006, V0007... refer to 4.1:1). The simple r_s correlation coefficients were as follows:

Variable	Coefficient of correlation (r_s)
V0005	-0.631
V0006	+0.483
V0007	+0.519

The results show that illiteracy correlates quite highly with mortality levels (life expectancy). On examining the internal correlation (correlations between these levels of education) we found that there is a very high correlation between the three variables. Females with 7+ years of schooling have a coefficient of -0.795 when correlated with illiteracy levels. And r_s of -0.856 when illiteracy correlates with males who have attained 9+ years of education. The high internal correlation implies that the three variables share the explanatory value of the variation which could have been explained by just one of them. Therefore, in the continuing discussion of the effect of education, it pays to ignore the two educational variables that have a lesser r_s coefficient and emphasise the one with a higher coefficient. This saves us the trouble of talking about each separately when in fact we are talking about the same thing.

Adult illiteracy in this study was considered to measure a variety of things:

1) Marginality and its associated style of living, e.g. poor sanitary conditions, poor sewage disposal, poor nutrition.
2) Low levels of income since employment in the modern sector is directly associated with educational merit.
3) Poor knowledge of child care and limited access to medical facilities.

In the multiple regression, illiteracy explains 18.8% of the variation which is quite substantial. The Beta value for illiteracy is -0.475 which means that a reduction of illiteracy by one percent (1%) will improve life expectancy by 2 years. A two year improvement of life expectancy by just 1% reduction is indeed impressive.

Although Caldwell emphasises female education, this may mean the same thing in this study. The illiteracy level considered here includes females as well, and it can also be seen (Appendix table 2), that illiteracy and female education correlate very highly. This means that the effect of female education operates through adult illiteracy to influence mortality levels. Female education other than income, works through other routes like knowledge of child care to reduce child mortality. But in an urban area, as this study has tried to show, survival rotates around income. Female education per se may not strongly influence child mortality levels, although it should have an income element. This is evidenced by the high correlation between father's education and mother's education. Therefore it may be concluded that educational levels for all sexes have been found to be of great importance in declining mortality levels in an urban setting like Nairobi.

4:2:2 Density per hectare by ward

This variable was intended to measure the degree of congestion in the dwelling units. But it has been found to have a very low correlation with mortality levels, although in the expected direction. The r_s for this is -0.0229 and it accounts for 0.2% of the variation. As stated in Chapter 1 density per hectare is a very crude measure for occupancy rates, otherwise occupancy rates when measured well may have a substantial impact on mortality levels, for most infectious diseases are known to spread fast in congested conditions.

4:2:3 Immigration (internal migration from rural to Nairobi)

Urban growth in less developed countries is determined by natural increases and immigration from rural areas. The rural urban migration is accelerated not only by rapid population growth but also by agricultural stagnation and lack of rural employment opportunities. The economic stagnation of urban centres (i.e. cities and towns) and the heavy population pressure on urban infrastructure - e.g. housing, water supply, waste disposal, transportation, etc. - have a considerable impact on the environment. Nairobi's population doubled in 10 years between 1969 and 1979. In 1969 the population was 509,286 and in the 1979 census it had increased to 945,000, which is a very high increase indeed within a period of 10 years. This increase and the related inadequate water supply and/or waste disposal systems, congestion and relatively low average urban income have in most cases, given rise to infectious diseases, deteriorated hygienic environment with diseases multiplying in certain depressed areas (i.e. slums and squatter settlements).

Other than the obvious pressures created by immigration as mentioned above, the study intended to examine how much immigration from high mortality areas and general immigration influences mortality variations in Nairobi. The results show a very high relationship between mortality levels and migration.

Variable	r_s coefficient
(1) % immigrants from high mortality regions	-0.648
(2) % immigrants from high mortality regions irrespective of the place of origin	-0.441

In the multiple correlation migration alone accounts for 64% of the variation which in no uncertain terms means that it is a very important variable among those considered in this study. This clearly shows that the mortality level in Nairobi is influenced by mortality experience elsewhere since these immigrants only came to Nairobi 12 months before the 1979 census. Consequently some of the women in this group are almost certain to have reported mortality experience which occurred in their home areas. Without denying this fact of misplaced reporting one must still emphasize that the status of a migrant in Nairobi is very crucial in terms of a child's chance to survive. Normally a migrant to an urban area sets out to look for "greener pastures" which in many cases are not realised. In fact the migrant frequently starts out in Nairobi at a very low living standard. Secondly the high correlation between migration and mortality statistically explains the importance of the duration of exposure to medical facilities. Although original homes of the migrants have prerequisites for disease vectors, e.g. mosquitoes, whose effect tends to persist for some time in the receiving area (Nairobi), the medical facilities and programmes that are available at least take a reasonable period to combat such ailments. If there weren't such facilities then an individual's period of stay could have not been significant in determining child mortality differentials as in this study.

Collectively the results show that if conditions of the immigrants are improved both at the receiving end and the sending ends by one standard deviation life expectancy can be raised by 4 years on average.

In addition to the above correlation analysis we utilized other modes of analysis to explore specific aspects of the intricate relationship among socio-economic, demographic (migration) and mortality factors.

4:2:5 Path analysis

This procedure is itself a type of regression analysis which allows us to explore the consequential question to what extent is immigration a function of the socio-economic factors used in the analysis? Hence their functional relationship to mortality levels. Immigration and illiteracy have a significant positive correlation of 0.3. Both variables together explain 83% of the variation in mortality levels, with 17% left to be accounted for by other considerations.

A convenient way of showing the interrelationship among the socio-economic, demographic and mortality variables is path analysis. In the following model we assume that both socio-economic and demographic (migration) variables have a direct impact on mortality decline, and that socio-economic (education factors themselves influence migration factors).

Path analysis is a statistical model in which "each dependent variable must be regarded explicitely as completely determined by some combination of variables in the system. In problems where determination by measured variables does not hold, a residual variable uncorrelated with other determining variables must be introduced".1/

A path coefficient is the Beta coefficient in a regression analysis and "gives the expected effect of a

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1/ Otis Dudley Duncan, "Path Analysis: Sociological Examples", American Journal of Sociology, 72, No. 1 (July 1966):3

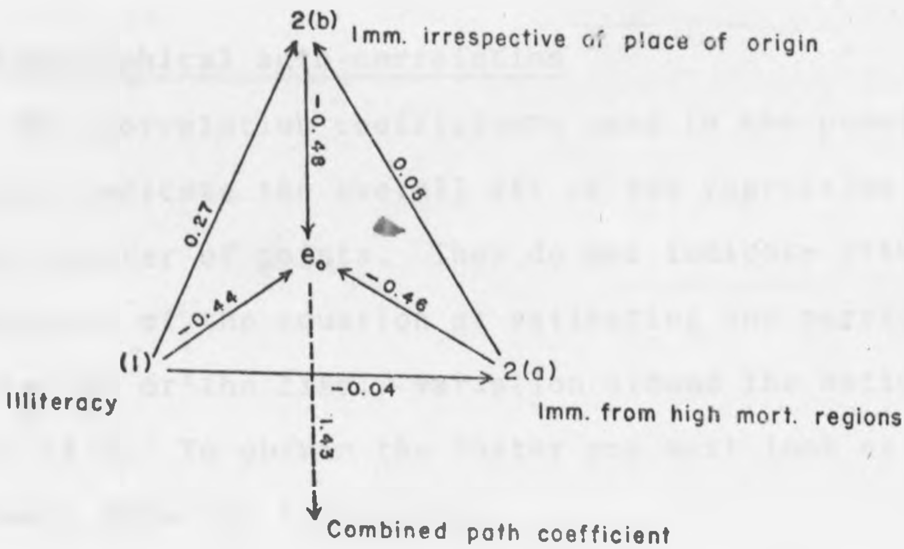
change in one standard deviation in the explanatory variable (holding other variables constant), this expected change is expressed in terms of the standard deviation of the predicted variable".[1/]

In order to use path analysis one must select a given variable or combine the socio-economic variables into a single variable - in this case illiteracy. For convenience, the mortality level (life expectancy has been labelled variable 0, illiteracy variable 1 and immigration variable 2. The correlations and path coefficient values for these variables are:-

Variables	Correlation coefficient	Path coefficient
01 Mortality level (e_o) and illiteracy	-0.63146	-0.4437
02 Mortality level (e_o) and		
a) Migration from high mortality regions	-0.64834	-0.46073
b) Migration irrespective of place of origin	-0.44127	-0.47546
21 Illiteracy and a, b migration		
2 (a & b) Migration general and migration from high mortality regions	0.05	—

1/ M.G. Kendall and C.A. O'Muircheartaigh, Path Analysis and Model Building, No. 2/Tech 414, World Fertility Survey, Technical Bulletins, March 1977

In the graphic presentation of the path analysis below, the arrows indicate the assumed direction of effect with the vertical broken arrow showing the combined effect.



According to this model, migration has a more direct effect on mortality levels (0.93) than education (.44). But this understates the total effect of education in as much as it also operates through migration. But the combined effect is quite high (1.43). This means that a change in one standard deviation of the independent variables will improve life expectancy by 5 years.

Finally for purposes of completeness in the analysis it is of great importance to examine the levels of prediction across the wards. The degree of prediction may not be the same in all the 40 wards. Therefore the following subsection is intended to check whether there is any pattern in the levels of prediction. This is done by geographical auto-correlation using residuals.

4:3 Geographical auto-correlation

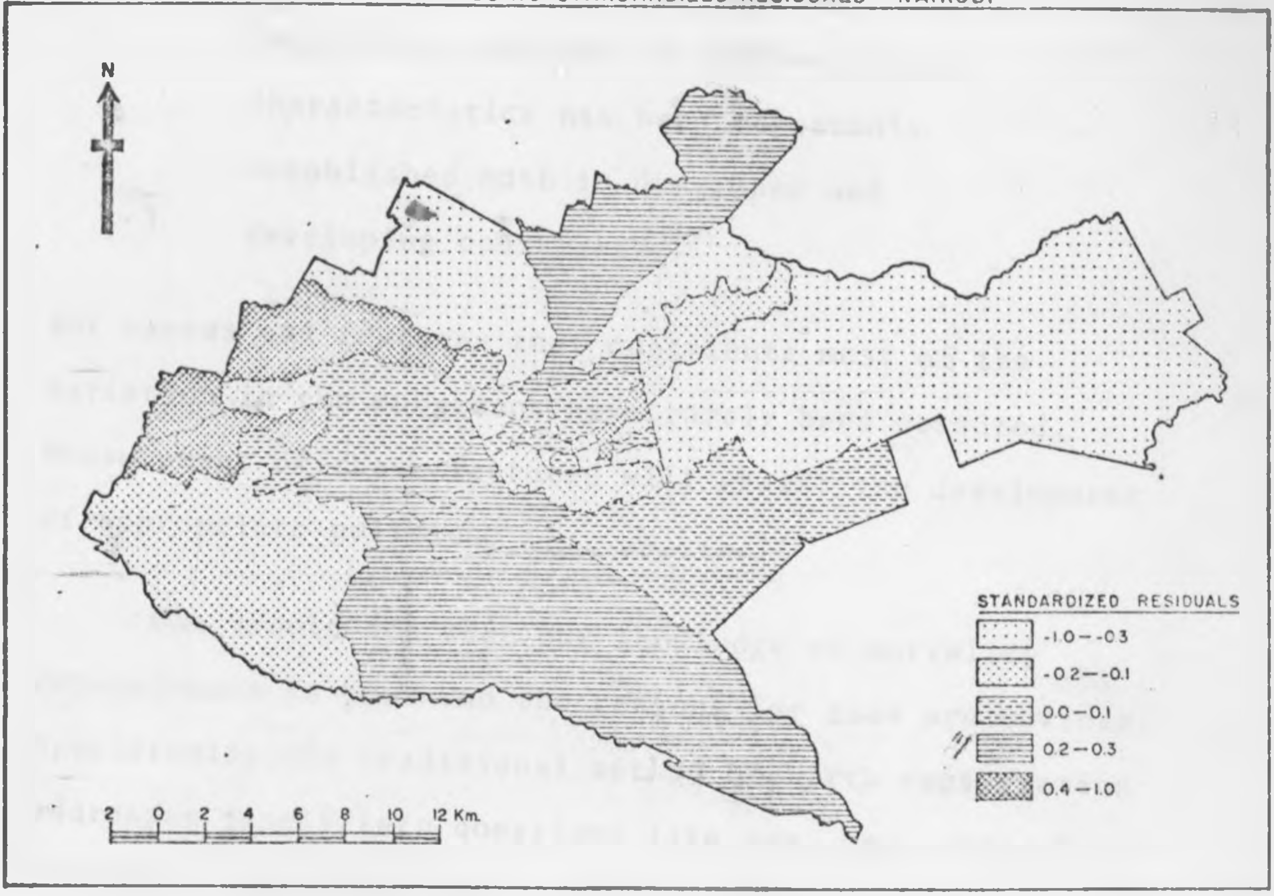
The correlation coefficients used in the previous analysis indicate the overall fit of the regression line to the scatter of points. They do not indicate either the success of the equation at estimating any particular observation or the likely variation around the estimated values of Y. To obtain the latter one must look at the residuals from the regression.

The residuals were obtained by devising a certain conventional programme and fitting the data into the computer. Results obtained from the computer are shown in Appendix table 4. The computer transformed the population residuals into standardized residuals which have two advantages: (1) They are associated with a clearly statistical distribution (the normal); and (2) They comprise bands which can run parallel to the regression line and they do not give undue emphasis to the residuals in Y related to either the large or small values of X (as do the absolute and relative residuals, respectively.

The print out of the standardized residuals by ward was then used to plot a map (see over-leaf). As the map makes it clear, we failed to establish any commonality in those wards which were poorly predicted. However as the map indicates the worst predicted wards are those at the urban fringes. Such wards contain very diverse socio-economic categories and as a consequence, have highly heterogenous populations. Given these characteristics, it is possible that if other variables like transport and parity would have been included in the regression the prediction might be improved. But generally speaking the variables used in the analysis were quite accurate in predicting mortality variations in Nairobi.

Finally to crown the study the next chapter is addressed to conclusions and recommendations deduced from the findings.

LEVELS OF PREDICTION BY WARD USING STANDARDIZED RESIDUALS — NAIROBI



CHAPTER 5

CONCLUSION

> "The existence of large variations in mortality levels among subgroups of populations defined by socio-economic characteristics has been repeatedly established both in developed and developing countries".[1/]

But causes and features that contribute most of the variation in the subgroups have rarely been measured. Measurement of these features will assist the development of appropriate policies.

One should add that our knowledge of mortality determinants is poor and the reasons for this are obvious. Specifically the traditional method of birth registration addresses itself into questions like sex, age, area of residence, ethnicity and religion without an indication of socio-economic characteristics and number at risk. Mortality differentials without socio-economic characteristics and number at risk, are difficult to unravel and to compare. Just knowing the number dead by sex or age without records on the number exposed to that risk has no meaning for purposes of comparison.

1/ William Brass "Policies for the reduction of mortality differentials". Population Bulletin of E.C.W.A. Number 19, December 1980.

Because of the frustrations and slow progress of research based on traditional data, new approaches have become popular. In this study for example we used the "linkage"scheme derived from Brass questions where the deceased is located in records of those "at risk". The comparability of the classification of numerator and denominator in the death rates was thus ensured and the range of variables widened. Variables were then taken from the census data for the living, which usually contain much more detail than the death records. The Brass questions used in this analysis are:

1) Children ever born to child-bearing mothers categorized into age groups
2) Children at home during the day of census
3) Children staying elsewhere.

Most studies carried out among individuals in a society have found out that in primitive societies the death rate is about 40 per 1000 and the life expectancy at birth some 25 years. In the countries of lowest mortality, the life expectancy is about 75 years; thus it is obvious that the level of mortality is strongly correlated with development, which creates the conditions necessary for improved health. In Nairobi we have found extraordinary contrasts in mortality. It is plausible that the characteristics of development most strongly related to improved mortality of other countries will also be important in the city of Nairobi. There have been many attempts to determine these characteristics but none has been particularly convincing. The two major difficulties are those of specifying well defined and comparable aggregate measures for the different subgroups and distinguishing the relative contributions of various factors. In general, those subgroups with the highest income will also have the highest levels of education, health services, environmental control and so on. Assessing the relative importance of these factors is then often dependent on a few cases of uneven development which are likely to be aberrant in other ways.

Nairobi's ward (estate) variations are extremely large, with a range of 8 mortality levels (20 years of life expectancy difference), between the lowest socio-economic areas and the better off middle income wards. Women born into higher classes have lower mortality among their children. The relationship with social class largely works through the amount of education that the father and mother receives. In this study we found that educational levels correlate quite highly with mortality levels. To survive in a city like Nairobi one must have at least some kind of employment and the level of employment depends on the level of education attained. It follows from this that levels of employment and income should have a substantial impact on the mortality experience of Nairobi's residents.

When socio-economic and clinical based variables were examined, they assumed an almost similar weight in determining mortality variations. The coefficient of adult illiteracy is -0.63, immigration from high mortality regions -0.65 and general migration -0.44. The combined effect of clinical variables (duration of exposure to clinical facilities as measured by immigration) and socio-economic variables if improved by one unit, improve life expectancy by 5 years.

RECOMMENDATIONS

Preston and Nelson (1974: Preston 1975) have provided the most persuasive basis for interpreting the broad influences on mortality changes. This work is well known and only the main relevant points need be noted here. Essentially, it is based on the level of mortality and living standards, as measured by national income per capita, changed from the 1930s to the 1970s. The significant findings are: (1) That life expectancy for a given standard 40 or 50 years ago, and (2) That after a threshhold level of national income per capita has been reached (and the threshhold is decreasing with time), the level of mortality is weakly related to income. The reasonable deduction is that progress in medical technology has lessened the dependence of health on wealth. In the present study there is not enough supporting evidence to claim that Nairobi has reached such a threshhold. On the contrary from our results both income and exposure to medical technology (as measured by the level of recent immigration from high mortality area) seem to have a more or less equal Beta weight of about 0.44. The major policy implication is that measures to reduce differentials within wards can be made successful by: (1) raising the educational levels of the people and (2) improving access to medical technology especially to new comers from high mortality areas outside Nairobi. A threshhold where levels of development are high enough not to cause differentials is not ripe yet for Nairobi.

Further studies by Preston have shown how declines in mortality by causes of death have been related to development. However rough and uncertain the assessment, the orders of size seem acceptable. Declines in influenza, pneumonia and bronchitis (diseases that have not been much affected by preventive measures) caused about one-third of the total decline. Clinical treatment played some part, but probably a small one. The decrease in deaths from diarrhoeal diseases was about one-tenth of the total gain, largely a consequence of improvements in water supplies and sanitation. Much of the remaining fall was due to reduced mortality from causes such as malaria, smallpox, tuberculosis, measles, etc; which are susceptible to direct preventive intervention through vector control and immunization. Without entering into difficult questions of definition and disease interactions, it would seem that approximately half of the mortality fall resulted from improvements in levels of living and half from medical technology.

Looking at standard of living and medical technology as separate entities may be misleading. Factors never operate in isolation, and often the combination of features is synergistic (i.e. greater than the component parts). A few examples may be illuminating. The rapid fall in mortality in Sri Lanka from 1945 to 1950 has been thoroughly studied by Newman (1970), Gray (1974), and others; it coincided with the malaria eredication programme, which undoubtedly made a large contribution to it. Estimates of the proportion of the total decline in mortality caused by this activity vary, but there is agreement that a substantial part was due to other factors that must have been interacting with the eradication. Similar programmes, for example, in Guatemala, appeared to have little effect. In a recent study, Macrea (1979) looked at childhood mortality trends in the British Solomon Island group from 1960 to 1972 where malaria eradication took place at different times. A substantial drop in mortality occurred following eradication in the less developed, higher-mortality areas but there was little decline in mortality in the more advanced parts with moderate mortality levels. In some conditions, large falls in mortality have been claimed following the introduction of simple preventive measures - for example in coastal areas of Papua and New Guinea (Seragg 1967) - but the efforts in the Matlab area of Bangladesh to reduce cholera and diarrhoeal diseases monitored from the mid-sixties to the present have been associated with little change in child mortality (Chowdhury and Sheikh, 1979).

Finally for purposes of creating a stronger basis for policy formulation on the Nairobi case, it will be of paramount importance to have an intensive micro study among those groups with highest child mortality levels. The study if anything should focus on causes of death. The major issue here is to try to avoid unnecessary death, for we must all die, sooner or later. The fact of socio-economic differential in mortality means that success has been achieved in one segment of the community which is not available to the other segments. Though we have concentrated on mortality, this must be set in the context not only of when we die, but of how we live.

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APPENDIX TABLE 1

TABLE ON AVERAGE DIVERGENCE OF THE POPULATION (l_2), AND THE ESTIMATED (l_2), AVERAGE MORTALITY LEVEL, AND SAMPLE SIZE PER WARD

Ward	Average Divergence	Average Mortality Level	Sample size per ward
1. KARIOBANGI	9	15.9	7,014
2. DANDORA	11	17.4	3,977
3. EASTLEIGH	6	18.7	9,566
4. MATHARE	2.3	16.0	11,027
5. MAKADARA	2/3	17.1	1,833
6. EMBAKASI	9	16.7	1,938
7. KAWANGWARE	9	16.5	4,111
8. KIBERA/WOODLEY	4.6	15.7	10,378
9. PUMWANI	7	16.0	2,674
10. PANGANI	5	20.4	3,427
11. HARAMBEE	2.3	19.0	2,957
12. NAIROBI SOUTH & WEST	2.6	20.1	5,884
13. UHURU	4.0	20.4	4,307
14. PARKLANDS	7	19.7	5,491
15. GOLF COURSE	13	18.6	3,600
16. KILIMANI	9.7	18.9	9,748
17. KARURA	10.6	15.1	483
18. KAREN/LANGATA	7.6	17.2	2,185
19. MUTUINI	4	20.3	1,121
20. WAITHAKA	2.6	20.9	1,191
21. UTHIRU	5.7	18.8	1,314
22. LUMUMBA	10	19	2,236
23. KANGEMI	7	17.7	3,645
24. NGARA WEST	6.6	20.2	2,213
25. NGARA EAST	2.3	19.0	3,464
26. MARINGO	2.6	18.3	2,067
27. INDUSTRIAL AREA	22.6	17.2	949
28. CITY CENTRE	2/3	17.0	3,377
29. NAIROBI CENTRAL	9.6	18.0	1,796
30. ROYSAMBU/KAHAWA	7	17.7	4,278
31. SPRING VALLEY	12	18.3	3,422
32. MUNGUMONI	11.3	18.1	2,190
33. RUARAKA/KASARANI	5.0	13.1	4,047
34. SHAURI MOYO	13	16.4	2,755
35. BAHATI	5.6	18.6	1,515
36. MBOTELA	7	16.6	2,080
37. MAISHA/MAKONGENI	8.6	15.0	2,347
38. KALOLENI	14.7	16.4	714
39. RIRUTA SATELLITE	8.3	18.4	2,946
40. ZIWANI/KARIOKOR	6	17.5	1,273

APPENDIX 2

PROCEDURE OF GRADUATING 1_2: MATHARE WARD USED AS AN EXAMPLE

The survival ratios for ages 2, 3 and - derived by Brass's basic method in Table (1) are 1_2, 1_3 and 1_5 respectively.

Let the logit transformation of 1_2, 1_3 and 1_5 be Y(2), Y(3) and Y(5) respectively; and let the corresponding logits in the African standard be $Y_s(2)$, $Y_s(3)$ and $Y_s(5)$ respectively.

Let ΔX be the mean of the derivations of $Y(2) - Y_s(2)$, $Y(3) - Y_s(3)$ and $Y(5) - Y_s(5)$.

Let $1'_2$ be the graduated 1_2.

For Mathare Ward

(1) Proportion surviving	(2) Logit Transformation	(3) Logit of the African Standard	(4) Difference (2) - (3)
1_2 = 901	Y(2) = 1104	$Y_s^{(2)}$ = 805	299
1_3 = 885	Y(3) = 1020	$Y_s^{(3)}$ = 725	295
1_5 = 874	Y(5) = 968	$Y_5^{(4)}$ = 682	286

$$\Delta x = \frac{566}{3} = 188.5 = 189$$

$$Y_s^{(2)} + x = 805 + 189 = 994$$

$$\therefore 1'_2 = 879$$

APPENDIX 3

VARIABLES AND RESULTS OF THE REGRESSION MODEL

VARIABLE LABELS - V0001: WARD/

V0002: MORTALITY LEVELS PER 1000/

V0003: % MIG. FROM HIGH MORTALITY AREAS 1 YEAR BEFORE 1979

V0004: TOTAL % MIG. PER WARD 1 YEAR BEFORE 1979 C/

V0005: % ILLITERATE PER WARD/

V0006: % FEMALES 15-49 YEARS OF AGE WITH 7+ YEARS OF SCHOOLING/

V0007: % MALES 15-49 YEARS OF AGE WITH 9+ YEARS OF SCHOOLING/

V0008: POPULATION DENSITY PER HECTARE BY WARD

STATISTICS

Variable	Mean	Standard Deviation
V0002	17.7975	1.7228
V0003	35.5000	14.4293
V0004	21.4750	6.9466
V0005	18.0500	7.0309
V0006	37.4000	15.8192
V0007	31.2750	8.0606
V0008	77.2750	92.6731

Cont'd .../ ...

APPENDIX 3 (CONTINUED)

SUMMARY OF THE MULTIPLE REGRESSION

Variable DEPENDENT VARIABLE ... V0002 MORT. LEVELS	R Square	Simple R	B	Beta	Std. Dev.
1. % Migrants from high mortality areas	0.42034	-0.64834	-0.05501	-0.46073	14.429
2. % Illiterate per ward	0.46264	-0.63146	-0.10872	-0.44370	6.9466
3. Total % migrants per ward	0.83139	-0.44127	-0.1112	-0.44346	7.0359
4. Population density per hectare by ward	0.83391	-0.2296	-0.00100	-0.05396	15.8192
5. % Males 15-49 years of age with 9+ years of schooling	0.83579	-0.51909	-0.0264	-0.012333	8.0606
6. % Females 15-49 years of age with 7+ years of schooling	0.83619	-0.48345	-0.00400	-0.03675	92.6731

Constant 23.648

Standard Variation for dependent variable = 1.7228

Source: Computer print out

APPENDIX TABLE 4

TABLE OF RESIDUALS

Ward	Residual	Standardized Residual
1. KARIORANGI	-0.270	-0.2
2. DANDORA	-0.525	-0.3
3. EASTLEIGH	0.257	0.1
4. MAKADARA	-1.027	-0.6
5. MATHARE	0.260	0.2
6. EMBAKASI	0.007	0.0
7. KAWANGWARE	0.973	0.6
8. KIBERA/WOODLEY	0.288	0.2
9. PUMWANI	-0.245	-0.1
10. PANGANI	0.433	0.3
11. HARAMBEE	-0.189	-0.1
12. NAIROBI SOUTH & WEST	0.358	0.2
13. UHURU	0.779	0.5
14. PARKLANDS	0.009	0.1
15. GOLF COURSE	0.391	0.2
16. KILIMANI	0.238	0.1
17. KARURA	-1.825	-1.0
18. KAREN/LANGATA	-0.224	-0.1
19. MUTUINI	1.219	0.6
20. WAITHAKA	1.103	0.5
21. UTHIRU	-1.294	-0.8
22. LUMUMBA	0.189	0.1
23. KANGEMI	-0.352	-0.2
24. NGARA WEST	0.008	0.0
25. NGARA EAST	-0.827	-0.5
26. MARINGO	0.806	0.5
27. INDUSTRIAL AREA	-0.006	0.0
28. CITY CENTRE	0.006	0.0
29. NAIROBI CENTRAL	-0.919	-0.5
30. ROYSAMBU/KAHAWA	0.302	0.2
31. SPRING VALLEY	1.797	1.0
32. MUNGUMONI	0.368	0.2
33. RUARAKA	-0.591	-0.3
34. SHAURI MOYO	0.008	0.0
35. BAHATI	0.256	-0.1
36. MBOTELA	-0.984	-0.6
37. MAISHA/MAKONGENI	0.008	0.0
38. KALOLENI	-0.388	-0.2
39. RIRUTA SATELLITE	-0.001	0.0
40. ZIWANI/KARIOKOR	-0.005	0.0

APPENDIX TABLE 5

MORTALITY RATE PER WARD BY THE INDEPENDENT VARIABLES

VARIABLES V0002 - V0008

Ward	V0002	V0003	V0004	V0005	V0006	V0007	V0008
1. KARIOBANGI	15.9	56	21	22	29	28	33
2. DANDORA	17.4	40	20	17	46	33	1
3. EASTLEIGH	18.7	34	20	16	42	38	70
4. MAKADARA	17.1	25	22	19	28	27	85
5. MATHARE	16.0	50	22	26	18	21	218
6. EMBAKASI	16.7	27	36	19	48	37	2
7. KAWANGWARE	16.5	59	15	32	17	18	34
8. KIBERA/WOODLEY	15.7	60	23	25	28	26	78
9. PUMWANI	16.9	34	18	32	19	19	355
10. PANGANI	20.4	25	17	10	55	43	127
11. HARAMBEE	19.0	39	18	8	55	41	181
12. NAIROBI SOUTH & WEST	20.1	26	20	9	62	43	24
13. UHURU	20.4	37	17	7	55	42	112
14. PARKLANDS	19.7	27	19	10	64	39	6
15. GOLF COURSE	18.6	28	29	12	57	41	27
16. KILIMANI	18.9	28	26	10	63	37	16
17. KARURA	15.1	30	24	26	38	28	2
18. KAREN/LANGATA	17.2	27	27	19	46	27	16
19. MUTUINI	20.3	20	4	30	21	14	18
20. WAITHAKA	20.9	17	8	23	16	23	14
21. UTHIRU	18.8	24	7	17	32	22	11
22. LUMUMBA	19.0	43	20	8	53	41	112
23. KANGEMI	17.7	44	17	16	33	28	37
24. NGARA WEST	20.2	20	17	11	59	44	79
25. NGARA EAST	19.0	23	20	9	53	43	139
26. MARINGO	18.3	37	18	20	32	27	404
27. INDUSTRIAL AREA	17.2	28	28	20	32	34	8
28. CITY CENTRE	17.0	20	34	22	35	36	16
29. NAIROBI CENTRAL	18.0	11	26	17	44	39	61
30. ROYSAMBU/KAHAWA	17.7	29	24	23	1	26	6
31. SPRING VALLEY	18.3	33	38	14	54	34	7
32. MUNGUMONI	18.1	31	29	15	14	34	1
33. RUARAKA	13.1	66	27	33	16	20	17
34. SHAURI MOYO	16.4	44	24	23	26	25	135
35. BAHATI	18.6	14	20	20	32	31	177
36. MBOTELA	16.6	49	20	13	30	27	187
37. MAISHA MAKONGENI	15.0	62	28	28	26	23	238
38. KALOLENI	16.4	66	18	15	41	30	102
39. RIRUTA SATELLITE	18.4	41	16	16	35	31	43
40. ZIWANI/KARIOKOR	17.5	46	21	15	41	31	107

APPENDIX TABLE 6

SUMMARY OF THE MULTIPLE REGRESSION

Variable DEPENDENT VARIABLE ... V0002 MORT. LEVELS NAIROBI	R square	Simple R	B	Beta	Std. D.
1. % Migrants from High mortality areas	0.42034	-0.64834	-0.05501	-0.46073	14.429
2. % Illiterate per ward	0.64264	-0.63146	-0.10872	-0.44370	6.9466
3. Total % migrants per ward	0.83139	-0.44127	-0.11792	-0.47546	7.0309
4. Population density per hectare by ward	0.8-391	-0.02296	-0.00100	-0.05396	15.8192
5. % Males 15-49 years of age with 9+ years of schooling	0.83579	-0.51909	-0.0264	0.12333	8.0606
6. % Females 15-49 years of age with 7+ years of schooling	0.83619	-0.48345	-0.00400	-0.03675	92.6731

Constant 23.648

Standard Variation for the dependent variable: = 1.7228

Source: Computer print out