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AN EMPIRICAL ANALYSIS OF MORTALITY
DIFFERENTIALS IN KENYA AT THE
MACRO AND MICRO LEVELS

by

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1. Introduction

In the post World War II period most developing countries (LDCs) have experienced a dramatic decrease in mortality rates. The most widely accepted view is that this decrease was largely independent of economic factors and was mainly due to factors associated with government actions, such as improved medical technology, disease control, and increased availability of medical facilities.¹ There are several arguments to support this opinion. First, mortality rates have fallen in virtually all parts of the developing world - even in areas which have not experienced extensive economic development. Second, mortality has fallen very rapidly in a number of countries - much too rapidly in these countries to be explained only by economic development during these short periods of time.

There are, however, increasing numbers of researchers who argue that economic factors have made an important contribution toward reducing mortality rates during the post-war period. They point out that even in Sri Lanka, where mortality rates fell dramatically following an anti-malaria campaign, they fell dramatically in previously non-malaria areas as well.² They also point out that gastro-intestinal infections are among the major causes of mortality in LDC's and that these are not very responsive to inexpensive forms of medical treatment.³

This paper analyses mortality differentials in Kenya in an effort to obtain a better understanding of the relationship between mortality and its causes. The analysis is carried out using two distinct data sets, one on the macro level of administrative districts and the other on the micro level of individual households. The district-level analysis relates mortality differentials based on the 1969 Kenyan Population Census for 41 administrative districts to measures of socio-economic conditions, health facilities, and disease prevalence in each district. The micro analysis uses data on individual births from a 1974 survey and relates mortality differentials at the household level to socio-economic characteristics of the household (including income, education, housing characteristics, and types of medical facilities used), to a macro-level measure of disease prevalence, and to demographic characteristics of each birth (sex, parity and year).

¹ G.J. Stolnitz, "A Century of International Mortality Trends", *Population Studies*, Vol. 9, No. 1 (July 1955), and G.J. Stolnitz, "International Mortality Trends: Some Main Facts and Implications", in United Nations, Papers of World Population Conference, Bucharest, 1974, *The Population Debate* (New York, 1975), Vol. 1.

² H. Frederiksen, "Determinants and Consequences of Mortality Trends in Ceylon", *Public Health Reports*, Vol. 76, No. 8 (August 1971), pp. 659-663, and H. Frederiksen, "Dynamic Equilibrium of Economic and Demographic Transition", *Economic Development and Cultural Change*, Vol. 14, pp. 316-22.

³ T.P. Schultz, "Inter-relationships between Mortality and Fertility", in *Population and Development*, ed. by Ronald Ridker (Baltimore, 1976).

Background information on Kenyan mortality levels and trends is presented in section 2. Both the district and household data are described in section 3. Section 4 presents a brief discussion of the theoretical determinants of mortality, while sections 5 and 6 present the results of the empirical analysis of mortality differentials at the district and household levels respectively. Section 7 summarises the principal findings.

As with most studies of mortality, there are problems of data quality, especially with the mortality data themselves. There are also problems of multicollinearity in the district-level analysis, making it difficult to distinguish the separate effects on mortality of highly correlated variables. Consequently, the results in this paper must be interpreted cautiously and must be seen as adding to knowledge in this field rather than offering definitive answers to all questions. It must not be forgotten that in Africa, information even on mortality levels and trends is often lacking.¹

2. Background

Changes in Kenyan mortality rates over time appear to have paralleled the experience of many other developing countries. In the late nineteenth century mortality rates were very high. Medical care was crude, warfare was always a threat, famines were fairly frequent, and malnutrition was prevalent. Although it is impossible to estimate life expectancy at birth for this period, it could not have been much above 30 years, and was in all probability lower.²

The arrival of the British near the turn of the century changed the situation - both favourably and unfavourably. The railway they built improved the transportation system greatly, thereby reducing the threat of localised famines. They also curbed inter-tribal warfare and improved medical care and sanitary conditions, especially for those living in the towns. Finally, they introduced more efficient crops - both cash and subsistence.³

On the negative side, the British brought their own warfare and their own form of death. Over 80,000 East African men are believed to have died in the First

¹ The following statement is indicative of the limited knowledge on mortality rates in Africa (underlining not in text). "Most students of African population believe that death rates are falling though there are few precise data to document such a trend." (United Nations, *Determinants and Consequences of Population Trends* (New York, 1973), Vol. 1, p. 153).

² If the 1948 estimate of life expectancy at birth was correct (35.5 years) and it was rising between 1924 and 1948 at one-half per cent per year, life expectancy at birth would have been 31.5 years in 1924. If life expectancy at birth had been rising by one and one-half per cent per year from 1924 to 1948, it would have been 25.2 years in 1921. Obviously the true rate of increase is highly conjectural, but it probably was somewhere between zero and that estimated for the post-1948 period (1.43 per cent).

³ This change has been so dramatic that today's major subsistence crop (maize) and major cash crops (coffee and tea) were virtually unknown before the British arrived.

World War¹, and thousands more died in the Colonisation Wars. In addition, diseases unknown to the Africans of the hinterland were introduced causing epidemics among the African population.²

The first rough estimate of mortality rates comes from the 1948 Census - an infant mortality rate of 184 (which implies a life expectancy at birth of about 35 years using Coale-Demeny North model life tables).^{3,4} By 1962 life expectancy at birth was estimated to have increased to about 44 years and by 1969 it was estimated to be about 48 years. Similar post-World War II trends in mortality to those encountered for Kenya as a whole are also found at the Province level, with life expectancy at birth increasing in both the low life expectancy area around Lake Victoria as well as in the high life expectancy area of the Central Highlands (see Table 1).⁵ In conclusion, life expectancy appears to have risen all across Kenya in the post-World War II period, but it is also clear that differences across the country continue to persist.

3. Data sources and mortality measures

The district level data used in the macro-level analysis of mortality are drawn primarily from Kenyan Government publications. In particular, 1969 Population Census data are relied upon heavily, especially for estimates of the demographic

¹ Charles Miller, *Battle for the Bundu* (Nairobi, 1974).

² "Accompanying the adventurers and traders who were 'opening up' East Africa, and the colonial administration, came a number of diseases new to East Africa which reached epidemic proportions because the African population had no immunity against them. Smallpox, chickenpox, measles, poliomyelitis, plague, influenza and whooping-cough all seem to have made their appearance in East Africa by at least 1890. Many of these diseases were killers." R.M.A. Zwanenburg, and Anne King, *An Economic History of Kenya and Uganda 1800-1970* (Nairobi, 1975), p. 9.

³ Ansley Coale and Paul Demeny, *Regional Model Life Tables and Stable Populations* (Princeton, 1966).

⁴ There are biases inherent in the procedure of converting survival probabilities at a specific age into estimates of life expectancy at birth using model life tables, since this procedure assumes a particular pattern of age specific mortality rates. While the Kenyan mortality pattern is believed to resemble that in Coale-Demeny North model life tables, there are important deviations from this pattern, especially in the adult years where age specific mortality rates are lower at given life expectancies at birth than in North model life tables (see J.G.C. Blacker, "The Estimation of Vital Rates from Census Data in Kenya and Uganda", in United Nations Economic Commission for Africa, *African Population Conference*, Accra, Ghana, December 1971), and J.G.C. Blacker, "The Estimation of Adult Mortality in Africa", *Population Studies*, Vol. 31, No. 1 (March 1977).

⁵ Central Province and Nyanza Province were the only areas in Kenya for which mortality rates were reported from the 1948 Census. In 1963 there were major provincial boundary changes and Nyanza Province was divided into two provinces (new Nyanza Province and Western Province). For Nyanza Province, the 1969 estimate of life expectancy at birth was made using a weighted (by population) average of new Nyanza Province and Western Province.

TABLE 1

Estimated life expectancy at birth in Kenya, Nyanza Province and
Central Province in 1948, 1962 and 1969^a

	1948 ^b	1962 ^c	1969 ^c
Kenya	35.5	44.4	47.8
Central Province	44.9	54.1	60.1
Nyanza Province ^d	29.5	37.5	42.5

^a Estimates of life expectancy at birth are only rough approximations.

^b Based on infant mortality rate reported in 1948 Census and Coale-Demeny North model life tables.

^c Based on proportion of births dying to women 20-24 years and to women 25-29 years, as reported in 1962 or 1969 Census using the Brass method and Coale-Demeny North model life tables.

^d The 1969 estimate for Nyanza Province was made using a weighted (by 1969 population) average of New Nyanza Province and Western Province.

variables. Life expectancy at birth for each district is estimated by converting the reported proportion of births surviving to women 20-24 years and 25-29 years from the 1969 Population Census into the probabilities of a birth surviving to age 2 years (l_2) and to age 3 years (l_3), using a procedure developed by Brass.¹ These survivorship probabilities are then used to estimate life expectancy at birth (LE) using Coale-Demeny North model female life tables², and the arithmetic average of the two LE estimates is used as the best estimate of LE. Estimates of life expectancy at birth by district are shown in Table 2. They appear to be fairly reasonable over-all. Thus, LE for Kenya as a whole is estimated to be about 50 years, while the estimate of l_2 is similar to that obtained from a large

¹ United Nations, *Methods for Estimating Basic Demographic Measures from Incomplete Data*, Manual 4 (New York, 1967).

² Under-reporting of child mortality biases upward estimates of survival probabilities and therefore estimates of life expectancy at birth. The use of female model life tables helps cause a counterbalancing downward bias in estimates of life expectancy at birth.

TABLE 2

Mortality levels and life expectancy at birth implied by
 l_2 , l_3 , and Coale-Demeny North model life tables, 1969^a

District/ Province	Unadjusted survivor- ship probabilities		Implied mortality levels		Implied life expectancy at birth in years
	l_2	l_3	l_2	l_3	$(l_2+l_3)/2$
KENYA	.8507	.8265	22.27	22.06	47.8
<i>Nairobi</i>					
Nairobi	.9039	.8895	25.84	25.72	56.8
<i>Central</i>					
Central	.9208	.8896	26.37	25.73	60.1
Kiambu	.9046	.8991	15.76	16.35	60.1
Muranga	.8870	.8722	14.62	14.65	53.9
Nyeri	.9446	.9139	19.21	17.37	63.2
Kirinyaga	.8897	.8574	14.81	13.44	52.8
Nyandarua	.9358	.8981	18.42	16.28	62.6
<i>Nyanza</i>					
Nyanza	.7863	.7544	8.50	8.44	38.6
Kisumu	.7650	.7664	7.43	8.99	38.0
Siaya	.7421	.7255	6.35	7.16	34.2
S. Nyanza	.7546	.7156	6.93	6.75	34.6
Kisii	.8686	.8311	13.36	12.31	49.4
<i>Western</i>					
Western	.8276	.7950	20.44	20.39	43.5
Kakamega	.8344	.7994	11.17	10.62	44.8
Bungoma	.8490	.8318	12.10	12.35	48.1
Busia	.7667	.7302	7.51	7.37	36.1
<i>Coast</i>					
Coast	.8246	.8024	20.03	20.72	43.4
Mombasa	.8569	.8394	12.60	12.76	49.2
Kilifi	.7866	.7802	8.52	9.66	40.3
Kwale	.8119	.7860	10.13	9.94	42.6
Lamu	.8515	.8192	12.26	11.57	47.3
Tana River	.7896	.8255	8.67	12.00	43.4
Taita Taveta	.8138	.8129	9.99	11.28	44.1
<i>Rift Valley</i>					
Rift Valley	.8924	.8664	25.00	24.30	54.7
Laikipia	.8969	.8883	15.33	15.52	56.1
Narok	.8950	.8799	15.16	15.05	55.3
Kajiado	.9111	.9139	16.40	17.37	59.7
Turkana	.9021	.8319	15.41	12.35	52.2
Samburu	.9097	.9079	16.29	16.98	59.1
Nakuru	.8699	.8346	14.45	12.50	51.2
Baringo	.8576	.8253	12.65	12.00	48.3
Kericho	.9185	.8808	16.97	15.17	57.7
Uasin Gishu	.9134	.9068	16.57	16.87	59.3
Nandi	.8969	.8822	15.33	15.26	55.8
Trans Nzoia	.8718	.8365	13.58	12.60	50.2
Elgeyo Mara	.9018	.9013	15.68	16.50	57.7
West Pokot	.8451	.8205	11.88	11.74	47.0

1.....

TABLE 2 (cont)

District	Unadjusted survivor- ship probabilities		Implied mortality levels		Implied life expectancy at birth in years
	ℓ_2	ℓ_3	ℓ_2	ℓ_3	$(\ell_2 + \ell_3)/2$
<i>Eastern</i>	.8616	.8436	12.90	12.98	49.8
Embu	.8763	.8560	13.88	13.73	52.0
Meru	.8800	.8779	14.13	14.98	53.9
Isiolo	.7713	.7921	7.74	10.24	40.0
Kitui	.8317	.8083	11.03	11.07	45.1
Machakos	.8684	.8343	13.14	12.47	47.0
Marsabit	.8027	.8265	9.37	12.06	44.3
<i>North-Eastern</i>	.8366	.8409	11.35	12.46	47.3
Garissa	.8321	.8481	11.06	13.19	47.8
Wajir	.8173	.8178	10.44	11.59	45.1
Mandera	.8599	.8594	12.79	13.47	50.3

^a Estimates of life expectancy at birth are only rough approximations.

Source of mortality data: unpublished data, 1969 Kenyan Population Census.

demographic survey conducted in 1973.¹ Nevertheless, one must remain cautious about these LE estimates, especially in the case of districts where LE estimates based on ℓ_2 and ℓ_3 differ substantially.

The principal data source for the household level analysis is the 1974 ILO/University of Nairobi Household Survey. This Survey was carried out by the authors in December 1974, in collaboration with Professors S. Ominde and J.N. Muinde of the Department of Geography, University of Nairobi. The interviewers were Form V (12th year) secondary students who interviewed in their home districts. Two questionnaires were administered to each household. Heads of household were asked questions regarding characteristics of the household and of the individuals belonging to it. Married women 15-49 years were asked questions about themselves and their children.

The households in the survey were chosen randomly from an enumeration of households in 45 sublocations in Kenya. The 45 sample sublocations were chosen by a stratified multi-stage sampling procedure. First, two districts were chosen from

¹ "The ℓ_2 of 874 derived from the schedule 'B' data compares favourably with the ℓ_2 of 857 as estimated for the sample area from the 1969 Census data." (Republic of Kenya, *Demographic Baseline Survey Report*, 1973 (Nairobi, 1975), p. 46).

each of Kenya's eight provinces¹; and secondly within each sample district, sublocations were classified into high, medium and low population density strata, with one sublocation being selected from each density stratum. The sampled sublocations included 36 rural and 9 urban sublocations.

The original sample consisted of approximately 7,000 households. However, due to poor weather and other problems encountered during the enumeration period, the number of households which were actually enumerated amounted to slightly more than 5,000.² Unfortunately, the proportion of the original sample which was successfully enumerated varied considerably across sublocations. In order to retain as much as possible of the character of the original sample, it was decided to code a random sample of the completed questionnaires, weighted by sublocation in such a way as to obtain 40 per cent of the original sample in each sublocation. Additionally, to enrich the sample for purposes of urban-rural comparisons (and for purposes of analysis), the original sample was retained in the case of urban sublocations (enumeration in urban areas was successfully completed since it did not confront any of the transport and communication problems which arose in the enumeration of rural areas). The total sample available for analysis consists of 3,180 households, 701 of which (22 per cent) were enumerated in urban areas.

For the household level analysis, information from the fertility history of married female respondents is used to measure survival probabilities. Each live birth is a unit of observation and mortality is measured by a binary variable which indicates whether or not the child survived to age three years (SURVIVE3).^{3,4}

As is common with household surveys there appears to be an undercount of infant and child mortality.⁵ Nevertheless, the mortality data from the survey appear reasonable in two respects. First, the undercount of mortality is similar to that reported in a large demographic survey in Kenya (Table 3) in which the mortality

¹ In the case of one province (Nairobi), only one district was selected because of the fact that the province and district boundaries are coterminous.

² The survey period coincided with the period of the "short rains" in several districts which made travel extremely difficult for interviewers and supervisors in many areas. In other areas, insufficient water and security problems frustrated efforts.

³ Although any age could be used, survival to age three years is used in the present study to measure infant and child mortality, since "one of the most striking features of African mortality is the heavy incidence of deaths in the second and third years of life relative to the normally high rates in the first". (W. Brass, "Introduction: Bio-Social Factors in African Demography", in *The Population Factor in African Studies*, ed. by R.P. Moss and R.J.A.R. Rathbone (London, 1975).

⁴ Births which occurred during the three years preceding the survey were excluded from the sample. Consequently all births in the analysis were exposed to at least three years of risk.

⁵ Using reported survivorship rates to women 20-24 years and 25-29 years from the survey, in conjunction with the Brass method and Coale-Demeny North model life tables, one obtains LE estimates of almost 70 years in urban areas, and just over 60 years in rural areas.

TABLE 3

Reported proportion of children dying to mothers 20-24 and 25-29 years by residence, Baseline Demographic Survey and present study

Age	Urban			Rural		
	Present study	Baseline study ^a		Present study	Baseline study ^a	
		Detailed form	Short form		Detailed form	Short form
20-24	.048	.058	.088	.082	.075	.131
25-29	.036	.058	.096	.082	.092	.153

^a Republic of Kenya, *op. cit.*

data were obtained in the same way as in the present survey, indicating that the under-reporting of mortality is probably not survey-specific but due to some underlying reticence to report mortality in detail.^{1,2} Second, the mortality data from the present survey are internally consistent in that first-order differentials generally meet *a priori* expectations (Table 4), and one would not expect this to be the case if the mortality data were systematically biased in the expected manner.³ Thus, while the level of mortality appears to be under-reported, there is reason to believe that this under-reporting may be random and that the reported differentials are reasonable.

4. The theoretical determinants of infant and child mortality

There is ample evidence that within countries, as well as between countries, survival rates and socio-economic conditions are positively related.⁴ Among other factors, wealthier people are likely to be better fed, to have better sanitary conditions, and to be more knowledgeable about personal hygiene. But knowing only

¹ The *Kenyan Baseline Demographic Survey* used two techniques to collect fertility and mortality data. One schedule asked for specific information on each birth (detailed form) and was similar to the procedure used in the present study; the other schedule was not detailed (short form), only asking for the total number of children born alive and the number which had died, and was similar to the schedule used in the 1969 Population Census.

² Similarly, child and infant mortality was under-reported in an intensive demographic survey undertaken in the Philippines when a birth by birth recording approach was used, but not when the short form was used (Francis C. Madigan and Alejandro N. Herrin, *New Approaches to the Measurement of Vital Rates in Developing Countries*, Smithsonian Institute, Interdisciplinary Communications Programme, Occasional Monograph Series No. 3).

³ One would expect a greater under-reporting of mortality among poor, uneducated and rural women.

⁴ I. Adelman, "An Econometric Analysis of Population Growth", *American Economic Review*, Vol. 53 (1963); G.B. Rodgers, "Income and Inequality as Determinants of Mortality: An International Cross-Section Analysis", (Geneva, ILO, 1977), mimeo.

TABLE 4

Percent of births born before 1972 surviving to age three years by
current residence, presence of malaria, year of birth and wife's education

	Percent of births surviving to age 3
<i>Residence (current)</i>	
Urban	97.3
Rural	93.9
<i>Malaria</i>	
Not endemic	95.1
Endemic	90.7
<i>Time period of birth</i>	
1965 or later	94.8
1960-1964	94.4
1955-1959	94.3
1950-1954	91.1
before 1950	91.6
<i>Wife's education (standards completed)</i>	
None	93.7
1-4	93.8
5-7	96.6
8 or more	97.3

income levels is not necessarily very informative. It would be better if one had information on particular factors which are likely to be related to survival probabilities. After all, income *per se* can not improve survival rates; it is rather the things income buys which do so, and some of these are probably more effective than others in reducing mortality rates.

For purposes of the discussion which follows, the theoretical determinants of mortality are divided into two broad groups: (1) individual and household characteristics, usually considered to reflect one's "standard of living"; and (2) environmental factors, usually considered to be the focus of government health policy. The following is a short list of the individual and household characteristics which are likely to have significant effects on mortality rates:

(a) Drinking water

Many diseases are water-borne. Thus, the purer and less contaminated the water supply, the less likely people are to become sick. At the household level, data are available in the survey on the use of piped water, well water or river/lake water. Expectations are that survival rates are highest in households using piped water and lowest in households using river or lake water.

(b) Toilet facilities

Many diseases are less likely to be transmitted when hygienic toilet facilities are available and are utilised. At the household level, data are available on the use of pit toilets, water closets or fields. Expectations are that survival rates are highest in households using water closets and lowest in households using fields.

(c) Nutrition

Health and nutrition go hand in hand. Better fed people are healthier in general and are more resistant to disease. Indeed, the relatively high fatality rates in LDC's compared with developed countries are frequently "not due to differences in virus virulence but to differences in the state of host nutrition".¹ Unfortunately there are no direct measures of nutrition at either the district or the household level. However, it is expected that income and mother's education are fairly good proxies for nutrition.

(d) Housing

Certain housing characteristics may have an effect on mortality. If people are not properly protected from the elements, certain types of infectious diseases are easier to contract. At the household level, data are available on the type of material used for the roof, floor and wall of the household's dwelling. In the micro-level analysis, a variable referring to whether or not the dwelling has a thatched roof is used as a general measure of housing conditions, and expectations are that survival rates will be lower in houses with thatched roofs.

(e) Personal hygiene and
preventive health

The probability that people become sick or, once sick, recover, depends on the family's knowledge of proper health practices. For example, the willingness to accept modern medicine and inoculation should affect mortality rates. Although no direct measures of such factors are available at either the district or the household level, it is expected that the mother's education is a good proxy for them.

(f) Access to medical care

While the availability of medical care is largely outside the control of the individual, there are important differences between households in the degree of access to the varying qualities of health care which are available. Again, while there are no direct measures of access to medical care, income and education are expected to serve as reasonably good proxies.

¹ M. Latham, "Nutrition and Infection in National Development", in P.H. Abelson (ed.), *Food Politics, Economics, Nutrition and Research* (American Association for the Advancement of Science), p. 71.

(g) Mother's health

The mother's health should be related to the probability of her children dying. Children born to relatively healthy mothers should be in relatively good health at birth and in addition they should be relatively well fed while nursing. In the household survey, married females were asked how they would rate their own health during the past 12 months.¹ Expectations are that mothers reporting "poor" or "terrible" health will have children with lower survival rates than average while mothers reporting "good" or "excellent" health will have higher survival rates than average.²

(h) Parity

Parity is observed to be related to birth weight and infant mortality rates in developed countries. While there are biological reasons for this relationship, economic factors may also contribute to the first-order correlation between mortality and parity, especially in developing countries since larger families put added strain on family resources. At the district level there is information on fertility rates, while at the household level there is information on the parity of each birth. Expectations are that survival rates and fertility rates (or parity) will be negatively related.³

(i) Sex of birth

Mortality rates are generally higher for male births than for female births, and this also seems to be the case in Kenya.⁴ In the macro analysis of mortality differentials it is unlikely that the sex ratio at birth varies so greatly across population subgroups as to affect over-all mortality differentials. However, in an analysis of mortality differentials at the household level, the information on the sex of each birth which is available in the survey, needs to be considered.

The preceding list is by no means exhaustive. It is meant merely to suggest some of the important individual and household characteristics which may affect mortality differentials among children. Excluded from the preceding list are factors related to the individual's environment - that is, factors which are largely outside the family's control (i.e., exogenously given as far as the family is concerned). Attention is now turned to the more important of these environmental factors.

¹ Married female respondents were asked the following question: "How would you describe your health in the past 12 months? Excellent, good, not bad, fair, poor or terrible."

² Although the health data in the survey refer only to a 12 month period, serious health problems are frequently chronic in nature, so that this measure of health may be indicative of the mother's health over a longer period of time.

³ It is important to realise also that an undercount in mortality causes an undercount in births *by definition*, with the result being a built-in negative relationship between fertility and survival rates.

⁴ The Kenyan Baseline Demographic Survey indicates that age specific mortality differentials by sex resemble those in other populations where male rates exceed female rates (Republic of Kenya, *op. cit.*, 1973).

(a) Medical facilities

The more medical facilities and trained medical personnel available, and the closer these facilities are to major population centres, the higher survival probabilities should be. It is important to note that, over time, changes in medical facilities and medical personnel are partly a function of growing income levels and partly a result of government policy. At the district level, there is information on the number of hospital beds and cots *per capita*. This variable is used as a proxy for the availability of all types of medical facilities in a given district. At the household level, there is information on the type of medical facilities used (e.g., hospitals, dispensaries, chemist, spiritualists). Expectations are that survival rates are higher with the more frequent use of hospitals. It is also expected that families which use traditional forms of medical care, such as spiritualists and medicine men, experience lower survival rates.

(b) Disease control

There are two distinct approaches that can be taken in disease control programmes. First, people can be inoculated against specific diseases (e.g., smallpox and polio). Alternatively, insect and other animal carriers can be killed in an attempt to reduce or eradicate diseases such as malaria. In either case, inputs tend to be relatively cost-effective, as compared to other types of medical services, in terms of improving survival rates. Unfortunately there are no data available on disease control programmes in Kenya, either at the district level or at the household level. Nor is it known which (if any) of the variables used in the analysis is likely to proxy for their effects.

(c) Disease prevalence

Variations in climate can have an important effect on mortality differentials if the climate in certain areas is particularly "receptive" to disease organisms and their carriers. In many countries, because there is insufficient variation in climate, this factor is not important in determining mortality differentials. This is not the case in Kenya, however, where climate varies greatly across the country, as humidity, altitude and temperature interact. In the areas along the coast and around Lake Victoria, the weather tends to be hot and humid. These areas are generally considered to have an unhealthy climate, and most of the important tropical diseases, such as malaria and cholera are present. In contrast, the area around the Rift Valley and in the Central Highlands is much cooler, since most of this area lies above 5,000 feet. It is generally considered to have a relatively healthy climate, and most tropical diseases are encountered there infrequently (although other diseases, such as pneumonia and tuberculosis, are more common). Lastly, a large part of Kenya's land area, mainly in the North and East, is semi-desert, hot and dry. It is sparsely populated, due to the low humidity, and, tropical diseases are generally not frequent. In both the district level analysis

and the household level analysis, disease prevalence is proxied for by whether or not malaria is present year around.¹ Expectations are that survival rates are lower in the malarial areas.

(d) The state of medical technology

At a given point in time, knowledge regarding control, prevention and cure of diseases is fixed. Thus, in a cross-section analysis of mortality differentials, it is not possible to observe the effect of changes in medical technology on mortality rates. As a result, any projections of future changes in mortality rates based on cross-sectional relationships are likely to underestimate actual changes in mortality rates.² At the district level, the analysis of mortality differentials is purely cross-sectional. However, in the case of the household-level analysis, the data on individual births refer to different time periods (anywhere between 1939 and 1971). In order to register the effects on survivorship of changes in the state of medical technology over the time period covered by the data, the year in which the birth occurred is used as an explanatory variable in the household-level analysis. *A priori* expectations are that it is positively related to the probability of survival.

5. Mortality differentials
between districts

As shown earlier, mortality rates have been falling in Kenya at least since 1948. But what about differences between Kenyan districts at one point in time? Are the large differences observed in 1969 (Table 2) related to socio-economic conditions in a consistent and logical way? If so, is it reasonable to use the observed relationships for estimating likely future changes in Kenya's average life expectancy at birth? To investigate these questions, mortality differentials at the district level in 1969 are analysed in this section using the technique of multiple regression.

At the district level, information on many of the theoretical determinants of mortality are not available. Nevertheless, there are sufficient data to allow a simplified analysis. Two variables, per cent of the population which is urban (PCTURBAN), and per cent of the adult population which is literate (PCTLIT), are used as proxies for such unobserved micro-level variables as nutrition, personal hygiene, drinking water, and toilet facilities. Both variables are expected to be positively related to LE.

¹ Whether or not malaria is endemic in the various districts of Kenya does not appear to have changed over time. "In Kenya, stage I [of the four stages necessary to eradicate malaria recommended by WHO] has been underway for 30 years." (J.M.D. Roberts, "Malaria", in *Health and Disease in Kenya*, ed. by L.C. Vogel (Nairobi, 1974), p. 315).

² This appears to have been the case with cross-national relationships analysed in 1930 and 1960 (S. Preston, *Mortality Patterns in National Populations* (New York, 1976)).

The total fertility rate (TFR)¹, which is estimated from 1969 Census data, is used as a proxy for the relative frequency of high parity births. It is expected that higher parity births will exhibit higher mortality rates. Thus, the higher TFR, the more births which are of higher parity, and therefore the higher infant and child mortality rates should be. A variable referring to the amount of quality-adjusted agricultural land per person (CLIMLAND) is used as a proxy for the level of rural income per capita. To construct this variable, estimates of the net availability of water, which is believed to be the major determinant of agricultural potential in Kenya, were obtained from data on rainfall and temperature from over 100 stations in Kenya. Although ignoring factors such as soil fertility, topology, drainage and availability of surface water, CLIMLAND is an improvement on the previous measure of agricultural potential in Kenya, which was based on only three rainfall categories.^{2,3}

Direct measures of the macro health factors are available at the district level. Disease prevalence in general is measured by whether or not malaria is endemic throughout the year for a majority of the district's population (MALARIA)⁴, and the availability of medical facilities is measured by the number of hospital beds and cots per capita (BEDS).⁵ Malarious districts are expected to have a lower life expectancy at birth while districts with more extensive hospital facilities are expected to have a higher life expectancy at birth.

The means and standard deviations of the variables are provided in Appendix A, while Appendix B gives the correlation matrix. As in most macro studies, there are a number of apparent problems. Collinearity between the explanatory variables is fairly high; the number of observations is relatively small; substantial measurement errors are probably embodied in some of the variables⁶; and certain, possibly important, variables are excluded from the analysis. Thus, results may be sensitive to one, or a few atypical observations, and specification error as well as errors of measurement may bias the results.

¹ The total fertility rate is a period-specific estimate of the average number of live births women have when they reach age 50 years.

² See International Labour Organisation, *Employment, Incomes and Equality in Kenya* (Geneva, 1972), p. 35 and Republic of Kenya, *Statistical Abstract 1974* (Nairobi, 1975), p. 103.

³ A detailed description of CLIMLAND is available in an unpublished mimeo (Richard Anker and James Knowles, "An Improved Measure of Agricultural Land Potential in Kenya"), Department of Geography, University of Nairobi (Nairobi, 1976).

⁴ Source of malaria data is: Republic of Kenya, *National Atlas of Kenya* (Nairobi, 1970).

⁵ Source of hospital bed data is: Ministry of Health, 1971, Republic of Kenya, cited in S.M. Kimani, "Economic and Social Development", ed. by L.C. Vogel *et al*, *op. cit.*, p. 56.

⁶ In particular, estimates of life expectancy at birth (LE) and the amount of quality-adjusted farm land per capita (CLIMLAND) are only approximations, even though considerable care has been taken in their estimation.

For convenience the variable names and definitions are listed below:

LE	Life expectancy at birth in years
PCTLIT	Per cent of adult population which is literate (i.e., has completed five or more school standards)
PCTURBAN	Per cent of population living in urban centres (i.e., towns with 2,000 or more people)
TFR	Total fertility rate
CLIMLAND	Hectares of quality-adjusted agricultural land per person, as measured by rainfall, temperature, population and agricultural land area
BEDS	Hospital beds and cots per thousand persons
MALARIA	Binary variable for presence of malaria (1 if malaria endemic throughout year, 0 if not).

Weighted least-squares estimates are presented in Table 5.¹ Equation 1 includes only the two general socio-economic indicators - the urbanisation rate (PCTURBAN) and the adult literacy rate (PCTLIT). Equation 2 adds the two "macro" health measures - presence of malaria (MALARIA) and hospital beds per thousand persons (BEDS), while equation 3 adds the two remaining variables - the total fertility rate (TFR) and the farm land proxy for rural income per capita (CLIMLAND). Equation 3 is then re-estimated, with the PCTURBAN and BEDS variables, which are highly correlated ($r=.93$), alternately deleted (equations 4 and 5). Finally, equation 3 is re-estimated with unweighted least-squares (OLS) in order to see to what extent the results are sensitive to the weighting procedure.

The results indicate that disease prevalence has a strong negative effect on LE in all equations in which it appears. Inclusion of the MALARIA variable causes the adjusted R^2 to rise from .09 in equation 1 to approximately .50, and the relationship between MALARIA and LE is significant at the 1 per cent level. Where malaria is endemic throughout the year, LE is about 10 years less, on average, than it is in areas where malaria is not endemic.

The results are somewhat inconclusive regarding the effect of PCTLIT on LE. Equation 1 indicates that adult literacy rates are positively and significantly related to LE at the 5 per cent level, with a rise in PCTLIT of 4 percentage points implying a rise in LE of about one year. Similar results are obtained in equation 5. However, when the BEDS variable is included, as in equations 2, 3, 4 and 6, PCTLIT is not significant at the .10 level. Although it appears that

¹ In order to correct for the presence of heteroskedasticity, the estimation technique of Aitkens generalised least-squares is used to estimate the first five regressions reported in Table 5. The district values are weighted by the square root of the district's population. This procedure would appear to have particular relevance for Kenya, since administrative districts range in size from 22,000 people to 785,000 people and the demographic data for the 1969 Population Census are based only on a representative sample. A similar procedure has been used by T. Paul Schultz in an analysis of regional birth rates in Taiwan (T.P. Schultz, "Explanation of Birth Rate Changes over Space and Time: A Study of Taiwan", *Journal of Political Economy*, Vol. 81, No. 2, Part II (March/April 1973)).

TABLE 5

Ordinary least squares results for district level analysis of life expectancy at birth for 1969

Variables	Weighted ^a					Unweighted
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	43.72	46.55	49.52	42.88	54.08	47.69
PCTLIT	.28** (2.25)	.13 (1.34)	.21 (1.45)	.15 (1.10)	.27* (2.01)	.19 (1.33)
PCTURBAN	-.04 (0.58)	-.13 (1.26)	-.14 (1.30)	x	-.04 (0.53)	-.11 (1.07)
MALARIA	x	-12.25*** (5.29)	-11.57*** (4.83)	-11.74*** (4.87)	-11.09*** (4.64)	-9.93*** (3.85)
BEDS	x	2.37 (1.63)	2.01 (1.30)	.60 (0.54)	x	1.62 (1.22)
CLIMLAND	x	x	.31 (1.05)	.36 (1.05)	.31 (1.03)	.34 (1.31)
TFR	x	x	-.62 (0.50)	-.11 (0.09)	-1.12 (0.93)	-.28 (0.21)
R ²	.14	.52	.55	.52	.52	.46
$\bar{R}^2$	.09	.47	.47	.45	.46	.37
F	3.01**	9.91***	6.85***	7.56***	7.72***	4.91***
N	41	41	41	41	41	41

^a Weighted by square root of population in each district.

*** Significant at the 1 per cent level

** Significant at the 5 per cent level

* Significant at the 10 per cent level

PCTLIT and BEDS are positively related to LE, the fairly high correlation between BEDS and PCTLIT makes it difficult to determine which of these variables has the more important effect on average life expectancy.

The coefficient of the urbanisation variable (PCTURBAN) is consistently negative and statistically insignificant in all equations in which it is included. It is even statistically insignificant in equation 5, where the BEDS variable, with which it is so highly correlated, is excluded. The negative sign on the coefficient of PCTURBAN is, moreover, inconsistent with *a priori* expectations. In Kenya, it appears that after adjustment is made for the higher educational levels (PCTLIT) and the more extensive medical facilities (BEDS) found in urban areas, the latter do not provide a healthier environment than that provided by rural areas.¹ At least part

¹ Note that the first order correlation between urbanisation and life expectancy at birth is positive (r=.15).

of the observed negative effect of towns on average life expectancy may be due to the high population densities and crowded living conditions which are found in the lower income urban settlements.

Both the farm land proxy for rural income per capita (CLIMLAND) and the total fertility rate (TFR) exhibit the hypothesised relationships with LE (positive and negative respectively), but neither relationship is statistically significant in any of the equations in which it is included. Adding these two variables (equation 3) does not change the results from those of equation 2 in terms of the sign and significance levels of previously included variables.

Finally, the results in equation 6, where ordinary least-squares estimation is employed, indicate that the results for the explanatory variables are not very sensitive to which of the two estimation techniques (OLS or GLS) is employed. There are no changes either in signs or significance between the results in equations 6 and 3.¹

In summary the empirical results reported above are generally consistent with *a priori* expectations in terms of sign. The percentage of the population which is literate, the amount of quality-adjusted agricultural land per capita, and the number of hospital beds per thousand persons were all found to be, as anticipated, positively related to life expectancy. Also as expected, disease prevalence (proxied for by the year-round presence of malaria) and fertility were found to be negatively related to life expectancy. Only the negative (and statistically insignificant) coefficient of the urbanisation variable was contrary to *a priori* expectations. However, many of the observed relationships were not statistically significant. Thus, the total fertility rate, the urbanisation rate, and the amount of quality-adjusted agricultural land per capita were consistently insignificant. On the other hand, the evidence clearly indicates, that greater disease prevalence has an important effect on life expectancy at birth in Kenya, while the evidence is somewhat inconclusive as regards the possible effects on life expectancy of education and medical facilities.

The district level analysis reported above implies that life expectancy at birth in Kenya should continue to rise and, moreover, that there may be the opportunity for relatively quick improvements in the high mortality malarious areas where about one-fourth of the people live. According to equation 2, LE will grow by about 13 years between 1969 and the year 2000 as a result of socio-economic change.² When one takes into consideration the positive effect of likely

¹ The empirical results also appear to be insensitive to the likely extent of measurement error. When equation 3 is re-estimated after excluding districts where estimates of LE based on λ_2 and λ_3 differ by more than five years (Nyandarua, Tana River, Turkana, Marsabit, Isiolo and Garissa), there are no changes in sign or significance.

² Assumptions for the year 2000 for this projection are: PCTURBAN (21.1), PCTLIT (90.0) and BEDS (4.00). The value for PCTURBAN is based on the assumptions that the over-all population growth rate continues to be approximately 3.3 per cent per annum and that the urban rate remains approximately twice the rural rate. The value for BEDS is based on the assumption that this variable will grow by 3.0 per cent per annum. The value for PCTLIT assumes that adult literacy (a current government policy objective) becomes virtually universal by the end of the century.

improvements in medical technology and disease control, especially in the relatively high-mortality malarious areas, it appears likely that life expectancy at birth in Kenya will be in the high 60s to low 70s by the end of the century.

6. Mortality differentials between households

The present section analyses mortality differentials between households, using micro data from the ILO/University of Nairobi survey. Before proceeding to this analysis, however, it is necessary once again to include some words of caution regarding the interpretation placed on the results. First, as is common with household surveys, there is an undercount of mortality. Although there are reasons to believe this under-reporting may be random (and if present should introduce a bias *against* observing many of the hypothesised relationships), one must nevertheless remain cautious about results obtained from an analysis of the determinants of mortality when the over-all mortality level itself is under-reported (see section 3).

Second, there is a major problem with time periods in the micro analysis arising from the fact that the dependent variable refers to a different time period from that of the independent variables. For example, in the case of a child born in 1960, his (her) probability of surviving to his (her) third birthday should depend on household characteristics at that time (e.g., the level of household income in 1960). However, in the present study, data on household characteristics are available only for the 1974 period (i.e., the time of the interview). This means that certain of the explanatory variables in the micro-level mortality regressions, particularly those referring to household characteristics which may have changed considerably over time (e.g., income, toilet facilities, drinking water, housing characteristics, and mother's health), are subject to a substantial degree of measurement error. Moreover, the magnitude of this measurement error is undoubtedly correlated with certain of the other explanatory variables (e.g., the year of birth). Under such conditions, one would expect the estimated coefficients of variables with a high degree of this type of measurement error to be biased downward, while the coefficient of the year of birth variable should be biased upwards, reflecting not only the effects of exogenous changes in the state of medical technology (see section 4) but also the effects of changes over time in the variables most subject to measurement error.

In the empirical analysis which follows individual births are the units of observation. The dependent variable is dichotomous: whether or not a birth survives to age three years. As such, it is a pure measure of mortality in the sense that all births have had the same exposure to death, in terms of time.¹

¹ For this reason, children born after 1971, who had not been exposed to a possible three years of life by the date of the survey, are excluded from the analysis.

Ordinary least squares estimation is employed¹, and the empirical results can be interpreted as providing an estimate of the effect explanatory variables have on the probability of a birth surviving to age three years.²

The survey data provide a much wider range of explanatory variables as compared to the district level data used in the preceding section. For example, it is known what type of drinking water households use, what type of latrine households use, what their income per equivalent consumer is³, where the household is located, the type of roof on the household's dwelling, the type of medical facilities used by household members, the mother's education, and a subjective measure of the mother's health during the preceding 12 months. Nevertheless, data on a number of theoretically important determinants of mortality are still missing. These include nutritional levels, personal hygiene, feeding practices for infants, and the quality of medical care. However, it seems reasonable to assume that income levels and mother's education will proxy for some of these unmeasured factors.

A priori expectations are that households using piped water (PIPE) and well water (WELL) as well as households using pit latrines (PIT) and water closets (WC) have higher survival rates than households using river water for drinking purposes or fields for defecation (excluded classes). Households with poorer quality dwellings, as reflected by their having a thatched roof (THATCHED), are expected to have lower survival rates. Households using spiritualists or medicine men for medical care (TRADMED) are expected to have lower survival rates, and households using hospitals (HOSP) are expected to have higher survival rates. Births to women residing in urban areas (URBAN) are expected to have higher survival rates (although the district analysis do not indicate this), as are births to women from higher income families (INCOME) and births to better educated women (ED1, ED2). Lastly, relatively unhealthy women (POORHLTH) are expected to have children with

¹ It is recognised that due to the presence of heteroskedasticity, estimation of the standard errors is biased when the dependent variable is a binary variable and ordinary least squares is used. Additionally, the disturbance term is bounded and hence at best only approximately normally distributed. These considerations suggest that one should be careful in making strong inferences on the basis of marginally significant estimated coefficients in the case of the regressions reported in Table 6.

² It is important to note that the coefficients reported in Table 6 are not directly comparable with those obtained in the district level analysis of the preceding section. To make them comparable one must know the relationship between changes in survival probabilities to age three years and changes in life expectancy at birth. A rough approximation to this relationship, according to Coale-Demeny North model life tables, is that a change in SURVIVE 3 of about .018 implies a change in LE of about 2.5 years at a life expectancy at birth of 50 years (approximately the life expectancy at birth in Kenya). Such a conversion factor is, however, likely to be on the low side for the present study, because the over-all level of mortality is under-reported.

³ Estimates of household income from the Survey are considered to be reasonably accurate, since detailed information was collected and edited on each of the major components of income - wages and salaries, businesses and farms.

lower survival rates, while relatively healthy mothers (GOODHLTH) are expected to have children with higher survival rates.

In order to specify correctly the factors affecting the probability that a birth survives to age three years, it is also necessary to include certain demographic characteristics of the birth (sex, parity and year), as well as a macro measure of disease prevalence. Male births (MALE), higher parity births (PARITY), and births occurring in malarious areas (MALARIA) are all expected to have lower survival probabilities, while births occurring in a more recent year (YEAR) are expected to have higher survival probabilities.

For convenience, variable names and definitions are reproduced below. Means and standard deviations of the variables used in the micro analysis are reported in Appendix C, while the correlation matrix for these variables is provided in Appendix D.

SURVIVE 3	binary dependent variable indicating whether birth survived to age three years (1 if survived, 0 if died)
PIPE	binary variable indicating use of piped water (1 if uses piped water, 0 if not)
WELL	binary variable indicating use of well water (1 if uses well water, 0 if not)
PIT	binary variable indicating use of pit toilet for latrine (1 if uses pit toilet, 0 if not)
WC	binary variable indicating use of a water closet for latrine (1 if uses WC, 0 if not)
INCOME	household income per equivalent consumer per annum in thousands of Kenya shillings (children under 15 years of age weighted one-half)
MALE	binary variable indicating whether birth is male (1 if male, 0 if female)
PARITY	parity of the birth (e.g., first, second)
YEAR	year of birth
ED1	binary variable indicating some formal education for the mother but probably less than literacy (1 if standards one to four completed, 0 if not)
ED2	binary variable indicating relatively high level of formal education for mother and probably literacy (1 if standard five or above completed, 0 if not)
URBAN	binary variable indicating urban residence (1 if urban, 0 if rural)
THATCHED	binary variable indicating whether dwelling has a thatched roof (1 if thatched, 0 if not)
TRADMED	binary variable indicating use of traditional medical care (1 if spiritualist or medicine man used, 0 if not)
HOSP	binary variable indicating use of hospital (1 if yes, 0 if not)
MALARIA	binary variable indicating endemic presence of malaria year around in the sublocation of residence (1 if present year around, 0 if not)
GOODHLTH	binary variable indicating whether woman reported that she was in "good" or "excellent" health during the last 12 months (1 if yes, 0 if not)
POORHLTH	binary variable indicating whether woman reported that she was in "poor" or "terrible" health during the last 12 months (1 if yes, 0 if not)

The micro-level empirical analysis is reported in Table 6. Equation 1 includes one measure of the household's socio-economic well-being (INCOME), a macro measure of disease prevalence (MALARIA) and the demographic characteristics of the birth (MALE, YEAR, PARITY). Equations 2 and 3 include additional socio-economic measures (ED1, ED2, URBAN), while equation 4 expands the set of explanatory variables to include housing characteristics and sanitary facilities (WC, PIT, PIPE, WELL, THATCHED), variables referring to the type of medical services used (HOSP, TRADCARE), and subjective measures of the mother's health (GOODHLTH, POORHLTH). Equation 4 is, then, re-estimated for the rural subsample (equation 5) in order to observe the robustness of the results with respect to stratification by location.¹

The results shown in Table 6 indicate that mortality differentials in Kenya are significantly related to all three groups of factors analyses - to disease prevalence in the area of residence, to demographic characteristics of the birth (especially sex and year of birth), and to the socio-economic status of the household (especially income, mother's education, mother's health, type of toilet facility, and type of medical services). The results of the micro analysis thus lend support to the principal finding of the district level analysis, that disease prevalence, as proxied for by the endemic presence of malaria has a strong negative effect on infant and child survival probabilities. The MALARIA variable is observed to have a very strong (and statistically significant) negative effect on survival rates in all the reported regressions. Children born to families living in malarious areas have a lower probability of surviving to age three years by about .05.

The micro analysis also indicates that certain demographic characteristics of a birth are significant determinants of its survival probability. Thus, male births have significantly lower survival probabilities than female births and births born further back in time have significantly lower survival probabilities than more recent births.² These results thus confirm with the present data set the upward time trend in survival rates which is believed to have occurred in Kenya as well as the lower survival rates for male births which have been observed elsewhere.³ There is, on the other hand, inconclusive evidence regarding the effect of parity on SURVIVE3. While PARITY is significantly related to SURVIVE3 at the 5 per cent level in equation 1 this relationship becomes insignificant after ED2 is added in equation 2.⁴

¹ The urban subsample, which consisted of only 708 births, contained too few deaths to permit a separate urban analysis.

² Due to the possibility that exogenous time trend may have proxied in the analysis for unobserved changes over time in certain of the socio-economic variables (e.g., income and housing characteristics), the estimated effect of YEAR may be somewhat over-stated.

³ Republic of Kenya, *op. cit.*, 1973.

⁴ When parity is specified in equation 4 as a series of binary variables (parity one, parity two, parity three and parity seven or above), the results do not indicate any strong non-linearity but they do indicate that parities one to three have higher survival rates than higher parity births. The coefficients and t-statistics are respectively as follows: .0133 (1.63), .0142 (1.68), .0115 (1.31) and .0045 (0.40).

TABLE 6

Regression results for survival of births to age three years
(t values in parenthesis)

Variables	Total sample				Rural sample
	(1)	(2)	(3)	(4)	(5)
YEAR	.0018*** (3.59)	.0013*** (2.59)	.0013** (2.49)	.0013** (2.54)	.0013** (2.29)
MALE	-.0098* (1.70)	-.0097* (1.68)	-.0099* (1.72)	-.0104* (1.81)	-.0120* (1.91)
PARITY	-.0031** (2.17)	-.0021 (1.46)	-.0020 (1.34)	-.0021 (1.43)	-.0017 (1.08)
MALARIA	-.0463*** (6.54)	-.0480*** (6.76)	-.0481*** (6.77)	-.0437*** (5.83)	-.0527*** (6.05)
INCOME	.0071*** (3.54)	.0052** (2.53)	.0045** (2.14)	.0036** (1.70)	.0060** (2.11)
ED1	x	-.0001 (0.02)	-.0003 (0.03)	-.0046 (0.59)	-.0051 (0.60)
ED2	x	.0276*** (3.33)	.0240*** (2.84)	.0165* (1.90)	.0225** (2.23)
URBAN	x	x	.0204** (2.13)	.0018 (0.13)	x
WC	x	x	x	.0234 (1.59)	.0214 (1.09)
PIT	x	x	x	.0160** (2.13)	.0144* (1.84)
PIPE	x	x	x	.0056 (0.64)	.0036 (0.39)
WELL	x	x	x	-.0108 (1.30)	-.0089 (1.03)
THATCHED	x	x	x	-.0049 (0.74)	-.0033 (0.46)
HOSP	x	x	x	-.0032 (0.52)	-.0044 (0.66)
TRADMED	x	x	x	-.0210 (1.57)	-.0294*** (2.03)
GOODHLTH	x	x	x	.0087 (1.27)	.0083 (1.10)
POORHLTH	x	x	x	-.0225*** (2.84)	-.0227*** (2.68)
Constant	.8491	.8748	.8730	.8727	.8730
R ²	.012	.013	.014	.020	.021
$\bar{R}^2$	.011	.012	.013	.018	.018
F	14.70***	12.21***	11.26***	7.63***	7.36***
N	6308	6308	6308	6308	5600

*** Significant at the 1 per cent level

** Significant at the 5 per cent level

* Significant at the 10 per cent level

The results in Table 6 provide fairly strong evidence that socio-economic factors have a significant effect on survival probabilities, and the observed effects are by no means small. According to equation 1, which includes only one general measure of socio-economic status (INCOME)¹, an increase in income per equivalent consumer of 6,500 Kenya shillings per annum has about the same effect on survival probabilities as residence outside a malarious area.^{2,3} While such a change in INCOME is large compared to the average for the sample as a whole (799 Kenya shillings), such a change is not so large when compared to the difference in Kenya between urban modern sector incomes and rural incomes.⁴ Thus, according to the results in Table 6, while future changes in average income levels may not have a large effect on the over-all survival rate in Kenya, survival rates for well-to-do Kenyan households should continue to be relatively high compared to the average for the country as a whole.

When variables referring to the mother's educational attainment and urban residence are added in equations 2 and 3, the positive effect of INCOME is reduced (while remaining significant), indicating that part of INCOME's effect in equation 1

¹ Note that since the three general socio-economic measures (INCOME, ED2 and URBAN) are positively correlated, specifying ED2 and URBAN in addition to INCOME, causes the significance of the over-all fit to decrease even though these additional variables are themselves significant. Consequently, for observing the effect on survival rates of a change in over-all socio-economic status, the coefficient of INCOME in equation 1 would appear to provide the most appropriate basis.

² There is some evidence that INCOME is non-linearly related to SURVIVE3. When a quadratic INCOME term is added to equations 1 to 5, it is significant at the .05 level in equations 1 and 2 (t-statistics 2.35 and 2.00 respectively), at the .10 level in equation 3 (t-statistic 1.82) and is insignificant in equations 4 and 5 (t-statistics 1.36 and 1.59 respectively); and there are no changes in sign or significance of previously specified variables. The linear formulation for INCOME reported in Table 6 was retained because the statistical significance of the joint F value for the linear and quadratic INCOME terms together was lower in the full specification (equation 4) than that of the linear term alone. For interested readers, the coefficients for the linear and quadratic INCOME terms in equations 1 to 5 were as follows: .0148 and -.000854, .0120 and -.000734, .0107 and -.000668, .0084 and -.000507, .0130 and -.000799. These results indicate that the elasticity of SURVIVE3 to changes in INCOME (at the mean) is about twice as high in the non-linear specification as in the linear specification.

³ Interest in the non-linearity of the income term derives from the fact that a positive linear and negative quadratic term, as encountered in the present study, imply that a redistribution of income from higher to lower income households would increase average life expectancy. These results are thus consistent with cross-national evidence that greater inequality in the distribution of income is negatively related to average life expectancy. See G. Rodgers, *op. cit.*

⁴ Given that the average modern sector wages in the manufacturing sector and in the government sector are about 8,500 Kenya shillings per annum (Republic of Kenya, *Statistical Abstract, 1975*), and that there are, on average, 1.6 earners and 3.6 equivalent consumers in urban households (Kenya 1968/69 Urban Household Budget Survey, unpublished data), this implies that the average income per equivalent consumer for urban households with modern sector employment is about 3,750 Kenya shillings per annum.

is due to its proxying for urban residence and mother's education. Children born to fairly well educated mothers (i.e., educated to at least standard five), and children born to mothers residing in urban areas, have significantly higher survival probabilities *ceteris paribus* whereas children born to mothers with only a little formal education (ED1) do not have significantly higher survival rates. The combined effect of ED2 and URBAN in equation 3 is quite large - being only slightly less than that of MALARIA, or equivalent to the effect of an increase in INCOME of about 5,000 Kenya shillings.

When the set of explanatory variables referring to housing characteristics, toilet facilities, source of water, medical care, and mother's health, is added in equation 4, the significance of URBAN is eliminated while the significance of ED2 and INCOME remains.¹ It appears that the higher survival rates observed in urban areas can be attributed to such other factors as the use of modern toilet and water facilities, while the effects of mother's education and household income do not work only through these other factors. These results are not surprising, since income can purchase many things, such as more food and better quality medical care, while more educated mothers are likely to use more nutritious foods and better sanitary practices than less educated mothers. Urban areas, on the other hand, are not inherently healthier places to live than rural areas.

Of the variables added in equation 4, those referring to the use of pit toilets (PIT) and poor health on the part of the mother (POORHLTH) are significantly related to SURVIVE3.² Moreover, the magnitude of these effects is fairly large, being approximately the same as that of five or more years of schooling completed (ED2) or an increase in INCOME of about 4,000 Kenya shillings. The other housing and health variables are not significantly related to SURVIVE3. Thus there is no statistical evidence in equation 4 that either the source of water supply (PIPE, WELL), the quality of the dwelling (THATCHED) or the type of medical care (HOSP, TRADCARE), has an effect on infant and child survival rates. Lastly, there is some reason to believe that use of a WC has a positive effect on survival rates, even though its coefficient is just insignificant at the .10 level (t-statistic 1.57), since its coefficient is larger than that of PIT.

To observe the robustness of the results in equation 4, especially with respect to the collinearity between certain of the independent variables and urban residence,

¹ In addition to the t-statistics for ED1 and ED2, which are reported in Table 6, the joint F-statistic for these two variables in equation 4 (2.47) is statistically significant at the .10 level.

² In addition to the t-statistics, which are reported in Table 6, the joint F-statistic for GOODHLTH and POORHLTH (9.14) in equation 4 is statistically significant at the .01 level, while that for WC and PIT (2.37) is statistically significant at the .10 level. The joint F-statistic for PIPE and WELL (1.17) and for HOSP and TRADCARE (1.36) are both statistically insignificant at the .10 level.

equation 4 was re-estimated for rural residents only (equation 5).¹ As expected, the results are similar to those in equation 4; there are no sign reversals and only one change in significance: the negative coefficient of the binary variable referring to the use of traditional forms of medical care (TRADCARE) becomes statistically significant at the .05 level. In equation 5, however, sizeable increases occur in the coefficients of INCOME and ED2. The results with the rural subsample thus support the earlier conclusion that mother's education and household income levels have a positive effect on infant and child survival rates, while providing new evidence that the use of traditional forms of medical care, at least in rural areas, reduces survival rates.

The results of the micro-level analysis are generally consistent with *a priori* expectations, and many of the observed relationships are statistically significant. The micro empirical results are lent additional credibility by the likelihood that the mortality data are under-reported in such a manner as to bias the results against observing a positive relationship between socio-economic status and survival rates. *Ceteris paribus* the probability of a birth surviving to age three years is significantly related to household income (positive), mother's educational attainment (positive), sex of the birth (negative for males), year of the birth (positive), use of traditional medical practices (negative), health of the mother (positive), and disease prevalence in the area of residence (negative). These results indicate that socio-economic development is an important contributing factor to declining infant and child mortality rates in Kenya. Moreover, the fact that income and mother's education are observed to have a significant positive effect on survivorship even in the presence of variables referring to housing characteristics, source of water supply, toilet facilities, type of medical care utilised, and mother's health suggests that these latter variables alone do not provide the only channels through which socio-economic development operates to reduce infant and child mortality. The micro results thus provide indirect evidence of the possible importance of such factors as nutrition and personal hygiene which were not measured directly in the present study.

7. Conclusions

This paper has presented an empirical analysis of mortality differentials in Kenya. After discussing estimates of past trends and current levels in life expectancy at birth in Kenya, mortality differentials were analysed at the micro and macro levels using two distinct data sets. The macro-level data set consisted of district level information from Kenyan Government sources, with the mortality data itself derived from the 1969 Population Census. The micro-level data set consisted of information from a 1974 household survey, with the mortality data derived from individual birth records (i.e., whether reported births survived to the age of three years).

¹ When equation 4 is re-estimated with the total sample, excluding URBAN, there are no changes in sign and only one change in significance (WC becomes significant at the 10 per cent level).

The results of both analyses indicate that regional differences in disease prevalence are a major cause of mortality differentials in Kenya. In areas where malaria is endemic throughout the year, life expectancy at birth is observed to be significantly lower. The results of both analyses also indicate that a rise in socio-economic status has a positive effect on survival rates, although the micro analysis provides more convincing evidence in this regard. According to the micro analysis, children born to higher income households, to mothers with relatively good health and high levels of education, to households using modern, as opposed to traditional, forms of medical care, and to households equipped with modern, as opposed to primitive, toilet facilities have significantly higher survival rates than do other children. Lastly, with respect to demographic variables (which could not be analysed with the macro data), the micro analysis indicates that male births have lower survival rates than female births and that there has been an upward trend over time in infant and child survival rates.

APPENDIX A

Means and standard deviations for district level variables (N=41)^a

Variable	Mean	Standard deviation
LE	49.54	7.91
PCTLIT	22.13	12.12
PCTURBAN	9.43	24.20
TFR	7.64	1.28
CLIMLAND	2.01	3.31
BEDS	1.60	1.74
MALARIA	0.20	0.41

^a Weighted by square root of population in district.

APPENDIX B

Correlation matrix for district level variables (N=41)^a

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) LE	1.00						
(2) PCTLIT	.36	1.00					
(3) PCTURBAN	.15	.61	1.00				
(4) TFR	-.03	.16	-.50	1.00			
(5) CLIMLAND	.18	-.19	-.10	-.22	1.00		
(6) BEDS	.21	.61	.93	-.50	-.09	1.00	
(7) MALARIA	-.64	-.13	.10	-.08	-.13	.11	1.00

^a Weighted by square root of population in district.

APPENDIX C

Means and standard deviations for household level variables (N=6413)

Variable	Mean	Standard deviation
SURVIVE3	.94	.23
YEAR	63.36	6.14
MALE	.52	.50
PARITY	3.25	2.08
MALARIA	.21	.41
INCOME	.80	1.44
ED1	.18	.38
ED2	.18	.39
URBAN	.11	.32
PIT	.66	.47
WC	.10	.30
PIPE	.24	.43
WELL	.16	.37
HOSP	.61	.49
TRADCARE	.05	.22
THATCHED	.51	.50
GOODHLTH	.47	.50
POORHLTH	.25	.43

APPENDIX D
Correlation matrix for household level variables (N=6413)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) SURVIVE3	1.00																	
(2) YEAR	-.04	1.00																
(3) MALE	.02	-.03	1.00															
(4) PARITY	-.02	.29	-.03	1.00														
(5) MALARIA	-.08	-.04	.00	-.00	1.00													
(6) INCOME	.04	.02	.02	-.04	.04	1.00												
(7) ED1	-.01	.03	.03	.01	.02	.02	1.00											
(8) ED2	.06	.20	.00	-.13	.06	.26	-.22	1.00										
(9) URBAN	.05	.08	.02	-.08	.03	.23	-.03	.28	1.00									
(10) PIT	.02	-.05	-.01	.07	-.04	-.01	.10	-.01	-.25	1.00								
(11) WC	.04	.07	.03	-.06	.06	.20	-.07	.27	.66	-.47	1.00							
(12) PIPE	.05	.09	.01	-.08	-.10	.15	.00	.18	.60	-.12	.48	1.00						
(13) WELL	-.05	-.02	.01	-.01	.24	.01	-.01	-.02	-.15	-.01	-.12	-.22	1.00					
(14) HOSP	.02	.07	-.01	-.03	-.13	.12	-.02	.17	.22	-.07	.17	.22	-.06	1.00				
(15) TRADCARE	-.03	-.00	-.00	-.02	-.03	-.03	-.04	-.06	-.02	-.13	-.05	.01	.15	.04	1.00			
(16) THATCHED	-.06	-.03	-.01	-.04	.10	-.22	-.07	-.23	-.25	-.18	-.25	-.24	.12	-.23	.12	1.00		
(17) GOODHLTH	.06	.04	.01	-.04	.01	.09	.02	.10	.15	.01	.12	.09	-.07	.01	-.07	-.11	1.00	
(18) POORHLTH	-.07	-.05	-.02	.06	.05	-.07	-.01	-.10	-.10	-.04	-.08	-.08	.08	-.04	.06	.13	-.53	1.00

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