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Determinants of Mortality Change and Differentials in Developing Countries

The Five-Country Case Study Project

United Nations
New York, 1986

NOTE

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PREFACE

For more than a decade the Population Division of the Department of International Economic and Social Affairs of the United Nations Secretariat and the Division of Health Statistics of the World Health Organization (WHO) have been co-operating on a series of studies of mortality and health issues in developing and developed countries. A selected list of recent publications includes *Levels and Trends of Mortality Since 1950,*[1] *Data Bases for Mortality Measurement: Papers of the Meeting of the United Nations/World Health Organization Working Group on Data Bases for Measurement of Levels, Trends and Differentials in Mortality,*[2] and *Sex Differentials in Mortality: Trends, Determinants and Consequences.*[3]

In 1981 the United Nations and WHO initiated a series of case studies of mortality determinants in five developing countries: Bangladesh, Guatemala, Kenya, Senegal and Sri Lanka. The purpose of the case studies was to examine the factors related to levels, trends and differentials in mortality in diverse populations in order to illustrate the options facing Governments for setting strategies for reducing mortality and improving health. The present publication is the result of those studies. The case studies were carried out with the collaboration of a number of investigators for the countries concerned. The United Nations and WHO would like to thank the following investigators for their willingness and desire to share their information and expertise among themselves and with the United Nations and WHO: S. D'Souza and S. Zimicki (Bangladesh); H. Delgado, E. Hurtado and V. Valverde (Guatemala); D. Ewbank, R. Henin, J. Kekovole and W. H. Mosley (Kenya); P. Cantrelle, I. L. Diop, M. Garenne, M. Gueye and A. Sadio (Senegal); and S. A. Meegama (Sri Lanka). Throughout the study period S. H. Preston provided continuing advice and guidance to the project investigators as well as to the United Nations and WHO. His commitment helped lead the studies to a successful conclusion. Acknowledgement is due the United Nations Fund for Population Activities, which made the present publication possible through a grant for mortality studies.

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[1] United Nations publication, Sales No. E.81.XIII.3.

[2] United Nations publication, Sales No. E.83.XIII.3.

[3] Published by the Australian National University Press, Canberra, 1983.

CONTENTS

List of tables

Page

LIST OF FIGURES

LIST OF MAPS

Explanatory notes

The term "country" as used in the text and tables of this publication also refers, as appropriate, to territories or areas.

The designations "developed" and "developing" economies are intended for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process.

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

The following symbols have been used in the tables throughout the report:

Two dots (. .) indicate that data are not available or are not separately reported.
A dash (—) indicates that the amount is nil or negligible.
A hyphen (-) indicates that the item is not applicable.
A point (.) is used to indicate decimals.
A slash (/) indicates a crop year, a school year or a financial year, e.g. 1981/82.

Use of a hyphen (-) between dates representing years, e.g., 1981-1983, signifies the full period involved, including the beginning and end years.

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

Annual rates of growth or change, unless otherwise stated, refer to annual compound rates.

Details and percentages in tables do not necessarily add up to totals, because of rounding.

I. MORTALITY STRUCTURE IN FIVE COUNTRIES – AN OVERVIEW

United Nations Secretariat *

Governments and scholars are increasingly coming to recognize that a long and healthy life is one of the most highly valued components of welfare. Individuals around the world rank good health at or near the top of the list of attributes that they seek for themselves and their families. Health and longevity are not simply intermediate goals on the road to economic development but are among the principal characteristics that define development itself.

In order to achieve higher levels of health and longevity, it is clearly necessary that governments and individuals know what means exist for improving those levels. This knowledge is not something that needs to be rediscovered in every household, hamlet and country; to a very important extent, developing countries face similar problems in attempting to advance health and have access to similar solutions. What is required is that knowledge produced in one locale be made available to others.

This volume is an attempt to summarize and synthesize information on factors influencing health and mortality in five developing countries. These countries have been chosen because they have made special efforts to understand the determinants of ill-health in their populations. This understanding has required mounting an unusual statistical effort to characterize mortality levels and trends, disease patterns, social variations in mortality, and/or the effects of social and health programmes on mortality. The countries have usually received assistance from international agencies, from individual developed countries or from foundations in these efforts. But in most cases the countries themselves have taken the initiative to improve their information on health and have supplied extra resources for that purpose, the fruits of which are available beyond the country's borders.

Diseases are studied in laboratories, where the organism is investigated, and in clinics, where pathogenic processes are examined. But only when study reaches the level of the large group – a population – can one investigate the impact of factors identified in the laboratory or clinic on social aggregates. Only at the population level can the relative importance of various diseases be delineated, and only at the population level can a proper assessment be made of means for combatting those diseases. Control measures that may appear perfectly effective in the laboratory face many resource constraints and institutional obstacles when deployed in the population at large. Population-based studies are thus required to study use-effectiveness, rather than simply laboratory-effectiveness. Although each of the five countries studied here has important population-based information on health and mortality, the nature of that information is very diverse. Sri Lanka presents perhaps the most unusual case because its information is principally derived from a national vital registration system that dates back to the early part of the twentieth century. Such systems are very rare in developing countries and they permit a broad-gauged view of the impact of various developments in the economic, social and health sectors on mortality over a broad sweep of time. The fact that those developments were sometimes regionally differentiated (e.g., the post-war antimalarial programme) and that the vital registration system also provided regional detail is of great assistance in identification of their impact.

The Bangladesh case study relies on information somewhat similar to that used in Sri Lanka. The large bulk of information from Bangladesh is derived from the Matlab area, where the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has maintained a continuous vital registration system since 1966. This system has also been used to characterize levels and trends in mortality and to investigate the impact of large-scale changes (e.g., the drought and famine of 1974). Although its regional and temporal scope is limited, the Matlab surveillance area has been the basis for a number of health intervention activities, facilitating study of the impact of programmes. Teknaf, a second area surveyed by the International Centre for Diarrhoeal Research, Bangladesh, also provides estimates of the effects of various interventions.

Kenya and Senegal lack usable vital registration systems, except in selected cities. Data from these cities are mobilized here in an attempt to derive some evidence on disease patterns, however unrepresentative they may be at the national level. Substituting at the national level for a vital registration system has been a series of demographic surveys. These surveys are exploited in the chapters to provide indirect evidence on levels and trends in mortality, especially among children. Kenya has an exceptionally extensive series of such surveys, permitting more confidence to be placed in the resulting estimates. Both countries have had continuous field investigations of the Matlab type, the most important of which is the one conducted jointly with France in the Sine-Saloum region of Senegal.

The Guatemala case study, which touches on other parts of Central America as well, uses all of these forms of data: national vital registration, which is somewhat incomplete but of good enough quality to yield valuable insights, particularly on causes and ages of death; sample surveys that help to clarify levels and trends in mortality, particularly among children; and carefully designed inter-

* Population Division, Department of International Economic and Social Affairs, United Nations Secretariat.

vention studies conducted under the auspices of the Instituto de Nutrición de Centro América y Panamá. These provide evidence on the impact of several experimental programmes on mortality.

Table 1 presents evidence on the approximate levels of mortality and of economic development in the five case study countries. Four of the five countries have levels of gross national product per capita that are less than half of the average for developing countries; Bangladesh has the second-lowest income in the world, according to World Bank rankings. Only Guatemala edges above the developing country average. Likewise, three of the five countries have levels of life expectancy that are below average for developing countries. Guatemala's level of life expectancy is in close accord with its ranking in income. But Sri Lanka's life expectancy exceeds the developing country average by 10.9 years, while its level of income is only one third of the average. On the other hand, Senegal (like much of West Africa) ranks considerably higher on an income scale than it does in mortality. The case studies shed a great deal of light on reasons for these unusual rankings. For example, the case study of Senegal describes with vivid numbers an extremely hostile disease environment, reflected in extraordinary seasonality and erratic trends; Meegama's study of Sri Lanka traces a prolonged period of development in the social and health sectors that is predicated on a high degree of popular participation in government decisions.

TABLE 1. ESTIMATES OF INCOME AND LIFE EXPECTANCY IN COUNTRIES INCLUDED IN THE CASE STUDIES

Country	*GNP per capita 1982 (1982 dollars)*	*Life expectancy at birth, 1980-1985*	*Life expectancy at birth, 1950-1955*
Bangladesh	$ 140	47.8	40.4
Sri Lanka	$ 320	67.5	56.6
Kenya	$ 390	52.9	38.6
Senegal	$ 490	43.3	34.7
Guatemala	$1 130	60.7	42.7
Less developed countries	$ 983[a]	56.6	47.0

Sources: World Bank, *World Development Report, 1984* (New York, Oxford University Press) and *World Population Prospects as Assessed in 1982* (ST/ESA/SER.A/86), table A-15.

[a] Computed from averages for income-level groupings.

SUMMARY OF RESULTS

All countries included in the case studies have experienced sizeable declines in mortality at the national level. As shown in table 1, developing countries as a whole gained nearly 10 years of life expectancy between the periods 1950-1955 and 1980-1985. Three of the five case study countries have rates similar to this figure. But Guatemala and Kenya appear to have progressed much more quickly than the typical rate. Progress was surely also extraordinarily rapid in Sri Lanka in the period before 1950-1955, because by that period its life expectancy already equalled the average achieved by developing countries 30 years later. So it is particularly fortunate that Sri Lankan data permit an examination of the factors involved in this early mortality decline. These declines can be traced back to the first decade of the twentieth century, when improved sanitation in the form of better water supply and sewage disposal systems were instrumental, particularly in Colombo. These improvements were extended into the estate sector in the 1920s with comparable results. Deployment of trained midwives was also apparently efficacious during the period, especially in reducing neonatal tetanus deaths. Anti-malarial programmes after the Second World War were clearly an important source of mortality decline in previously malarial zones; but it is clear from developments in non-malarial areas that other factors were also at work, the most important of which were probably an extensive food grain distribution system and use of antibiotics. Meegama attributes the mortality decline since the 1950s to improved use of both preventative and curative medicine and to better sanitation. For example, the failure of malarial deaths to rise sharply despite a resurgence in the number of cases is possibly attributable to more effective use of anti-malarial drugs and to the improved overall physical condition of the population.

A key underpinning of the Sri Lankan successes in mortality reduction was the extension of the franchise to all adults, regardless of sex, in 1931. Meegama points out that Sri Lanka was the first Asian country in which women were enfranchised, a move that was justified explicitly on grounds of the high levels of infant mortality then prevailing. Popular participation in government decision-making has produced one of the clearest examples of national policy oriented towards satisfying the basic needs of the population, including the achievement of high levels of literacy.

In the other countries, which lack the data system present in Sri Lanka, it has not typically proven possible to treat the effects of national policies in such detail. Instead, the effects of particular programmes are usually examined regionally. The Guatemala case study reviews the effects of three health intervention programmes on mortality. All three were dominated by characteristics identified with the phrase, "primary health care". They involved the use of auxiliary health workers whose mandate was broad rather than targetted to a particular disease. The programmes entailed vaccination against diphtheria, pertussis, tetanus, polio and measles; vaccination of pregnant women against tetanus; health education and promotion; efforts to improve sanitation; simple curative measures; and a variety of attempts to improve diets and dietary practices. In two of the three areas, infant mortality fell spectacularly, and in the third it showed more modest declines. Various examinations of individuals involved in the interventions showed the expected relations; those receiving a greater programme "dose" typically showed greater improvement on health indicators. It should be noted that the interventions were carried out with a before-after design, and did not include control areas. However, the fact that the mortality improvement in two of the three areas was so large—apparently much larger than in Guatemala as a whole during equivalent periods—is substantial evidence that it was the programmes themselves that were responsible for the improvements. The studies provide substantial ammunition for advocates of primary health care approaches to developing country health systems and form a basis for a suggested organization of a primary health care scheme.

In the other countries, the health interventions were somewhat narrower in scope. A Bangladesh programme of vaccinating pregnant women to prevent neonatal tetanus reduced the death rate from this important cause by about half for women who were vaccinated. A diarrhoea treatment centre is estimated indirectly to have reduced death rates by 9-14 per cent. A programme of oral rehydration therapy in the home apparently reduced the number of visits made to clinics, but did not have an appreciable effect on mortality, possibly because death rates from dehydration were already very low because of the clinics. A large-scale maternal and child health/family planning programme in the late 1970s coincided with a sharp drop in the crude death rate (and an even larger drop in the crude birth rate), but the definitive studies have not been completed that would establish the link between these two events. Close to half of the crude death rate drop appears to be a result of age-distributional changes induced by the fertility decline.

In Senegal, a national campaign to distribute an anti-malarial drug (chloroquine) to all children under 15 appears to have reached about one third of the children and to have resulted in a drop of one third in the number of children seeking medical attention for malaria. A measles vaccination campaign in the period 1967-1969 initially reached about 75 per cent of the children but was conducted sporadically thereafter. In Ngayokhème, where no additional vaccination occurred until 1979, the number of new cases rose to their pre-1966 levels. The vaccination was far from totally effective even where it continued, presumably because the vaccine quality was variable.

Annual data from Ngayokhème since 1962 have revealed enormously high levels of child mortality, levels that many would have thought to have passed out of existence without such clear evidence of their continued presence. This continuous registration system in the Sine-Saloum area enables examination of the health effects of a natural experiment in the form of a drought in the early 1970s. Unlike the case of Bangladesh, one effect of the drought in Senegal seems to have been a sharp reduction in mortality because it reduced the prevalence of mosquitoes and hence of malaria. This difference in reaction points clearly to the need to recognize the disease environment as an independent actor in developing country mortality, while illustrating at the same time the value of comparative case studies.

Analysis of the Kenya data indicates the extremely important role played by the education of mothers in explaining the mortality decline. This is consistent with results from a number of other countries. The data showed, however, little relationship between district mortality and availability of health services. The authors indicate that this surprising finding may be because utilization of services was the key variable, rather than availability. There is evidence that utilization of services may be related to the increased education of mothers, especially at the three-year mark.

Case studies for Bangladesh and Senegal wrestle with the thorny problem of establishing cost estimates for various health interventions. The per capita costs of the primary health care programmes tested in Guatemala were on the order of $2 per capita per year. In Bangladesh, the calculation was taken one step further to provide a crude estimate of the cost of averting a death as a result of activity of the treatment centre. This cost was estimated to be $48-$102 per death averted. But D'Souza notes that the cost could be as much as 12 times higher, depending on how overhead costs are allocated. Complicating cost estimates in both countries is that one programme often saves resources authorized for another programme; oral rehydration therapy in Bangladesh and the primary health care interventions in Guatemala resulted in reduced attendance rates at pre-existing facilities. Clearly, some form of centralized planning is useful to take account of this interdependence.

In addition to describing activities that have proven successful or unsuccessful in altering levels of mortality, the case studies also provide a rich description of mortality conditions that can be used as the basis for structuring future programmes. In some instances these descriptions emphasize the cause of death structure. The case studies of Bangladesh, Guatemala and Sri Lanka show clearly that neonatal tetanus can be sharply reduced through vaccination campaigns. So when tetanus remains a serious cause of death, as in Bangladesh, a feasible remedy is immediately suggested. Likewise, the success of anti-malarial campaigns in Senegal and Sri Lanka points to a feasible strategy for reduction of the high rates remaining in Senegal. In these cases, information on causes of death can be almost self-explanatory in designing health intervention strategies. In a similar vein, the tremendous seasonality of mortality in rural Senegal points clearly towards important causal mechanisms underlying its mortality profile.

Knowing the level of mortality from certain other causes of death, such as diarrhoeal or respiratory disease, has less value in designing health programmes since the diseases themselves are not defined precisely enough that they have a straightforward aetiologic implication. Furthermore, they can be attacked through many routes. Unfortunately, in developing countries a very large fraction of child deaths fall into these more nebulous categories. As a rule, mortality conditions, including causes of death, are even less well-defined among adults in developing countries than are conditions among children. The analyses of adult mortality in chapters on Kenya and Sri Lanka are therefore especially welcome. In Sri Lanka, an alarming pattern is developing in which cardiovascular mortality for males has been rising sharply, repeating a pattern seen earlier in many developed countries. In Kenya, nearly one fifth of all deaths are due to the "diseases of development": cardiovascular disease, cancers and motor vehicle accidents.

Analogous to evidence on cause of death structure, descriptions of very large socio-economic differentials in mortality in the various case studies point to social and economic strategies for improving health conditions. These improvements are usually sought in their own right, but recognition of the health benefits can provide additional support and direction for policies. There is somewhat less uniformity in results in the various chapters on this score than might have been hoped. The failure of education of parents to appear as a variable significantly affecting child mortality in Senegal is particularly puzzling, since this variable has been shown to have a large effect on mortality nearly everywhere that it has been studied, including in chapters for Bangladesh, Kenya and Sri Lanka. On the other hand, urban residence appears far more important a variable in Senegal than it normally is elsewhere. The meaning of these findings for Senegal is not yet clear and clearly calls for further study.

These results suggest that the meaning of social variables can vary rather considerably from place to place and that the relations often need to be investigated at the national or subnational level. But even in such instances, comparisons across case studies help to establish the social context that shapes this meaning. In the case of sex differentials in child mortality, for example, the Senegal study shows clearly that differences are negligible in childhood (except for measles, which may be higher for girls because they socialize earlier). But in Bangladesh, there is a clear pattern of excess female mortality after the neonatal stage. It is demonstrated that this is likely to reflect a culturally conditioned reaction to scarcity by showing that excess female mortality increased sharply during the famine of 1974-1975. In Sri Lanka, which had a similar sex mortality differential in earlier times, the pattern has disappeared as general mortality conditions have improved.

The studies thus use a wide variety of data and approaches to address a common set of questions: what are the main sources of variation in mortality today, including such disparate matters as climate, malnutrition, illiteracy and health sectoral inadequacies, and what means have proven effective in the past for altering those conditions?

II. THE MORTALITY TRANSITION IN SRI LANKA

*S. A. Meegama**

INTRODUCTION

Public health and other social science researchers have paid considerable attention to the rapid mortality decline that took place in the developing world during the first two decades after the Second World War. The sheer rapidity of this decline distracted attention from the slow consistent declines which had occured during the previous period. Similarly in Sri Lanka, researchers of mortality change have centred attention almost solely on the three-year period following the Second World War, during which time crude death rates dropped from over 20 per 1,000 to just above 12. Little attention has been given to the even larger, albeit slower, declines that took place during the first half of the twentieth century, when crude death rates fell from well over 30 per 1,000 to just 20. The unbalanced attention is due not only to the striking rapidity of the post-war decline, and academic interest in determining precisely the proportion of the post-war decline due to the malaria programme, but also to a general view that mortality declines that took place over half a century ago without the benefit of Western technology have little relevance for current programme formation. However, it may well be that the Sri Lankan approach to disease eradication and health improvement during the first half of this century is most germane to current conditions of reduced national and international resources for mortality reduction. Further insight as to how, for example, levels of neonatal tetanus, malaria, diarrhoea and infectious diseases (all diseases still prevalent in many developing countries) were reduced or eliminated in Sri Lanka may throw valuable light on potential approaches today for other developing countries with minimum resources and little skilled manpower.

This study hence concentrates on mortality change in Sri Lanka (then Ceylon) during the pre-1950 period. However, in some cases, reference is made to more recent mortality statistics when more recent occurrences provide examples of what mortality structure may have been like during the earlier period. For example, numerous references are made to the effect of the 1974 famine on mortality patterns as illustration of the possible effects of the more numerous famine years on mortality during the late nineteenth and early twentieth centuries.

A major aspect of mortality in Sri Lanka before the 1940s was the great variation in disease types which existed between areas. Although the ecology of disease depended partially on climate and topography (mainly affecting prevalence of the malarial mosquito), it was also affected by social and economic forces which led to the dispersal and congregation of the population and to the development of sharp regional and social class divisions. The areas of the country which had been extensively changed by the new plantation economy based on export agriculture (coffee, tea, rubber and coconut) were the districts of the south-west zone, the central hills and the Jaffna peninsula. A little over 70 per cent of the population of the country was concentrated in this area (see map 1). Mortality in these regions was much lower than in the rest of the country, namely, the districts of the dry zone other than the Jaffna peninsula.

Although the plantation economy in the developed zone meant that many households did not grow their own food, they were employed either on the plantations or in ancillary activities and could depend on the market for imported rice, sugar, dried fish and other consumer needs. Thus, except during periods when the plantation industry was in serious crisis, food availability was not a major consideration in this region, except for the poor, who were perennially short of food. Also the provision of uncontaminated water and sanitation made headway in the developed zone. The developed areas were also provided with hospital facilities and maternal and child welfare services. Conversely, the dry zone population consisted mainly of a peasantry who lived on subsistence agriculture based on a slash-and-burn cultivation subject to periodic crop failures. In addition, the dry zone was away from the urban centres, which had developed to service the plantation economy, and it was thus less likely to adopt new ideas related to public health.

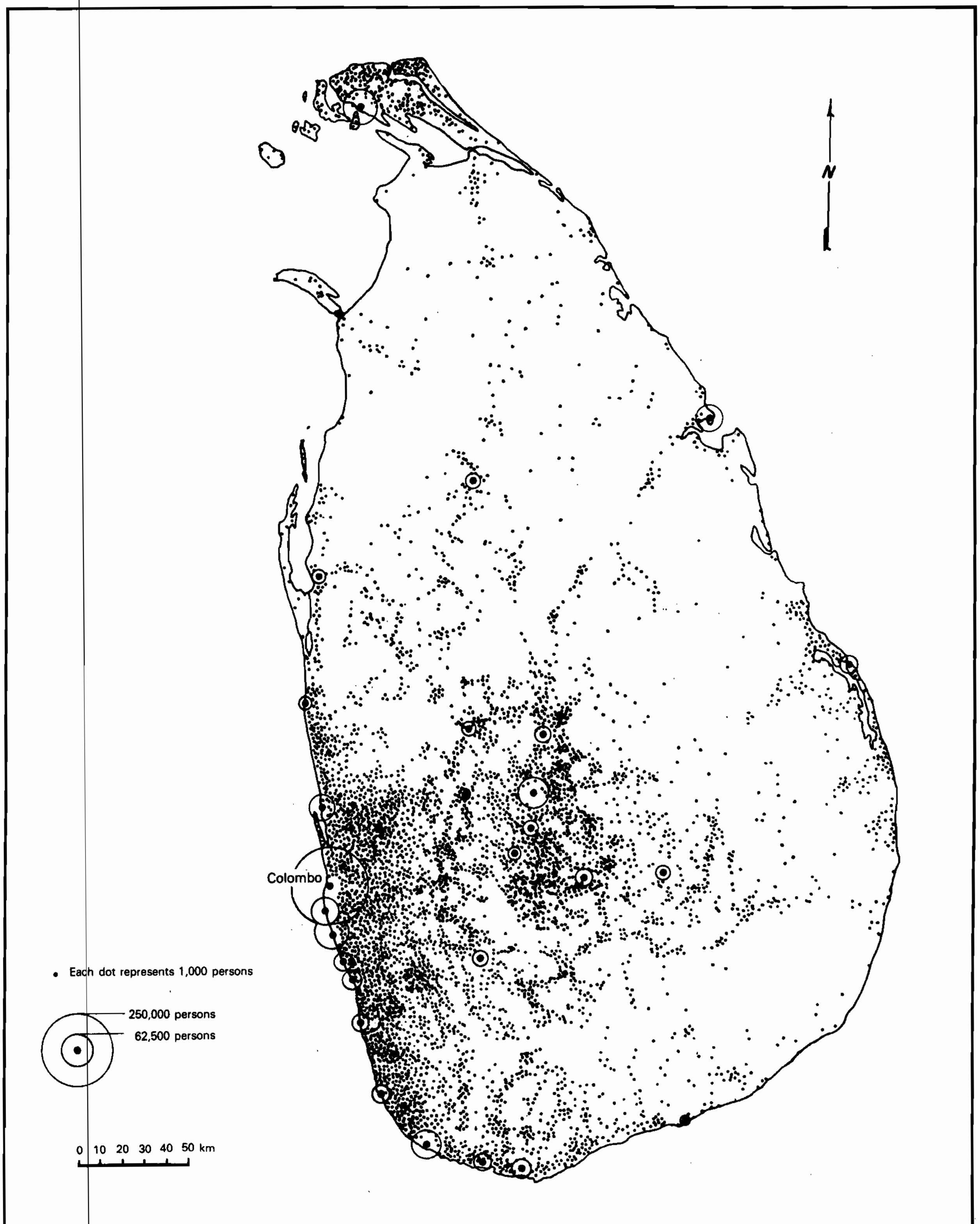
The differences between these two zones were not restricted to availability of food, employment, health services and living conditions. Due to the rainfall patterns and topography, the dry zone was plagued with endemic malaria which was to a great extent absent from the developed hill regions. In the central hills of the country, where the terrain did not permit the collection of stagnant pools of water, malaria was not a significant disease. (Parts of the developed region, however, were visited by periodic malaria epidemics which led to cyclical and explosive rises in mortality.)

The main diseases leading to high mortality in Sri Lanka during the period before the mortality transition can be classed under the following five broad categories.

Famine and malnutrition. Nutritional problems were one of the major factors leading to a high death rate from diarrhoeal diseases and respiratory infections. Famine and starvation, as a result of crop failure, were frequent occurrences among the peasantry in the nine-

* Department of Census and Statistics, Government of Sri Lanka.

Map 1. Ceylon: distribution of rural and urban population, 1946



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Source: The Economic Development of Ceylon; Report of a Mission organized by the International Bank for Reconstruction and Development at the request of the Government of Ceylon (Colombo, 1952), map 2.

teenth century, while malnutrition and undernutrition were common among the mass of the people throughout the period. The importance of the nutrition factor can be gauged by the effect on estate mortality of the food shortages of 1974.

Diseases due to insanitary conditions, contaminated water and soil pollution. The main group of diseases in this category were cholera, dysentery and enteritis, typhoid and ankylostomiasis. These were transmitted by the contamination of drinking water supplies due to poor sanitary facilities or, as in the case of hookworm, by infestation due to soil pollution. The problem was most acute in the rapidly growing urban centres of the country, in the plantations where large numbers of labourers were housed in line rooms with no sanitary facilities and in those rural areas that were densely populated.

Airborne diseases. The main airborne diseases were the respiratory infections resulting in pneumonia and bronchitis. Poor housing among large sections of the population gave insufficient protection against the damp tropical climate, especially in the cold damp central hills as well as in the humid south-west maritime zone. Tuberculosis, although not a widespread problem in the country, was a significant cause of mortality among the poor in the city of Colombo and in the plantations.

Maternal and infant mortality. Maternal and infant mortality in the nineteenth century and the early decades of this century were at very high levels mainly due to the unhealthy practices adopted by traditional midwives during and after delivery. In particular this situation led to the prevalence of very high neonatal mortality and to many deaths from sepsis among mothers.

Malaria. Malaria which was spread by the vector anopheles mosquito had diverse effects on mortality in the country. In the dry zone malaria was endemic and mortality was very high. Although the rest of the country did not have endemic malaria, many districts were affected by periodic epidemics which led to sharp rises in mortality, culminating in the catastrophic epidemic of 1934-1935.

The next section provides an overview of the structure of mortality levels and trends in Sri Lanka up to around 1950. The sections that follow consider the five health problems itemized above.

A. An overview of mortality trends and differentials

Reliable registration figures depicting the trend in mortality are available from the first decade of this century and the figures show that the crude death rate was over 30 per 1,000 in 1910. There is no doubt that mortality was at a much higher level during the nineteenth century and that it decined during the second half of that century due to a reduction in the number of deaths associated with undernutrition and starvation as well as to a reduction in deaths from cholera epidemics. However, the decline that took place from around 1910 is well documented statistically.

TABLE 2. MORTALITY TRENDS IN SRI LANKA, 1911-1981

Year	*Crude death rate (per 1,000 population)*	*Infant mortality rate (per 1,000 live births)*
1911-1915	30.6	201
1916-1920	30.1	190
1921-1925	27.8	190
1926-1930	25.1	175
1931	22.1	158
1932	20.5	162
1933	21.2	157
1934	22.9	173
1935	36.5	263
1936	21.8	166
1937	21.7	158
1938	21.0	161
1939	21.8	166
1940	20.6	149
1941	18.3	129
1942	18.1	120
1943	20.8	132
1944	20.8	135
1945	21.5	140
1946	19.8	141
1947	14.0	101
1948	13.0	92
1949	12.4	87
1950	12.6	82
1951	12.9	82
1952	12.0	78
1953	10.9	71
1954	10.4	72
1955	11.0	71
1956	9.8	67
1957	10.1	68
1958	9.7	64
1959	9.1	58
1960	8.6	57
1961	8.0	52
1962	8.5	53
1963	8.5	56
1964	8.8	57
1965	8.2	53
1966	8.3	54
1967	7.5	48
1968	7.9	50
1969	8.1	53
1970	7.5	48
1971	7.7	47
1972	8.0	46
1973	7.7	46
1974	9.0	51
1975	8.5	45
1976	7.8	44
1977	7.4	42
1978	6.6	37
1979	6.5	38
1980	6.1	34
1981	6.0	n.a.

Source: Economic and Social Commission for Asia and the Pacific, *Population of Sri Lanka; Country Monograph No. 4* (Bangkok, 1976) and Sri Lanka, Department of Census and Statistics, *Bulletin on Vital Statistics, 1978.*

Mortality trends from 1911 to 1981 are exhibited in table 2. Especially in the earlier decades, the pace of decline described therein is certainly understated, since the registration of deaths was improving rapidly because of the continuing implementation of the 1899 law relating to the registration of births and deaths.* Overall at a national level there was a sustained decrease in mortality in the period 1920-1942, during which time the crude death rate fell from around 30 to between 18 and 20. The decline ended abruptly after 1942, almost certainly due to the food shortages that occurred from that year until 1946. Sri Lanka, being a food-deficient country, was heavily dependent on rice imported from Burma, and with the outbreak of the war in the Far East there was a serious shortfall in the supply of rice. This was to some extent compensated for by flour imports but, as table 3 shows, there was a distinct shortfall in the supply of imported cereals during these years.

The crude death rate fell sharply in the few years thereafter, from 20 in 1946 to 14 in 1947 and 12 in 1949. This rapid decline of eight points in three years should be viewed in the light of not only malaria eradication, the extension of maternity and child welfare and the use of antibiotics, but also a return to normalcy in food imports upon which the country depended. The decline should also be viewed in the context of the continuation of a trend between 1936 and 1942 which had been broken in the war years.**

The other aspect of mortality trends in this period was the year-to-year fluctuations in death rates which were characteristic of most districts. This was so both in those areas that had endemic malaria as well as in those that were visited only by periodic epidemics, though in districts free of malaria the year-to-year fluctuations were very much less. The main factor causing these fluctuations was the periodic increase in malarial intensity, but the intensity of those crises was accentuated by crop failure and periodic food crises which are a characteristic feature of rain-fed agriculture.

In the first half of this century there were great variations in mortality between regions and between social classes within the same region. Death rates differed greatly between the dry zone and the developed south-west zone, as exemplified by a comparison between the North Central Province, a typical province in the dry zone with endemic malaria, and Kalutara, a maritime district in the south-west whose economy was based on the cultivation of rubber and which was free of both endemic and epidemic malaria (table 4). Among all age groups, mortality in the dry zone was greater than that of the south-west zone, the differential greatest for infants and those aged between 15 and 64. For females aged 15 to 64 mortality in the dry zone was more than 200 per cent higher.

The period from 1920 to 1946, before the eradication of malaria, saw a fall in mortality throughout the coun-

TABLE 3. CEREALS IMPORTS TO SRI LANKA, 1935-1952
(1,000 cwts)

Year	*Flour*	*Rice*	*Total*
1935	383	10 665	11 048
1936	288	10 419	10 707
1937	286	10 319	10 605
1938	314	10 449	10 763
1939	380	11 675	12 055
1940	363	10 996	11 359
1941	443	10 937	11 380
1942	1 797	4 710	6 507
1943	4 066	2 772	6 838
1944	5 913	2 239	8 152
1945	4 400	3 577	7 977
1946	4 251	5 074	9 325
1947	5 862	5 163	11 025
1948	3 373	8 188	11 561
1949	3 339	7 936	11 275
1950	3 311	9 808	13 119
1951	4 284	7 915	12 199
1952	4 159	7 986	12 145

Source: Customs returns of Ceylon.

TABLE 4. AGE-SPECIFIC DEATH RATE PER 1,000 OF THE SINHALESE POPULATION, 1920-1922

	Male			*Female*		
Age group	*Developed zone (Kalutara) (1)*	*Dry zone (North Central Province) (2)*	*Percentage difference (3)*	*Developed zone (Kalutara) (4)*	*Dry zone (North Central Province) (5)*	*Percentage difference (6)*
0-1	114.3	335.3	193	101.1	306.5	203
1-4	31.1	55.0	77	41.8	66.1	58
5-14	8.2	13.4	63	10.1	13.6	35
15-24	7.0	14.9	113	8.4	27.1	223
25-34	8.7	23.2	167	11.2	31.0	177
35-44	10.3	29.8	189	11.9	33.7	183
45-54	17.6	46.5	164	12.9	46.4	260
55-64	29.3	63.4	116	28.0	83.2	197
65+	108.6	181.1	67	120.1	195.1	62
All	20.6	42.1	104	21.9	48.1	120

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1920 to 1922 and from the 1921 census of Ceylon.

* Prior to 1899 each registrar of births and deaths did not have exclusive jurisdiction over the registration division in which he worked. Divided responsibility meant that there was no effective supervision of the registration of deaths. Ordinance No. 9 of 1899, which came into effect throughout Sri Lanka in that year, gave each registrar exclusive jurisdiction within a division. The extent of under-registration differed by regions. In the more developed regions, registration was better than in the rest of the country; however, even in these zones there was heavy under-registration in the estates during the first two decades of the century and it was only with the setting up in the early 1920s of a separate department to enforce the Medical Wants Act of 1912 on the estates that registration became almost complete in this sector, so much so that it was better than in most other parts of the developed region.

** A last phase in the mortality decline can be identified, from 1950 to the present, marked by a gradual decrease which by the 1970s had led to near stability in the mortality levels among some age groups.

try. The pace and structure of the decline in the two zones is illustrated in tables 5 and 6.

It is pertinent to note that the decline was common to both sexes and to all age groups in both regions and that the extent of the decline was also similar among most age groups. This would seem to indicate that the factors causing the decline were common to all age groups in both regions, e.g. a general improvement in nutritional levels, or an improvement in the quality of drinking water or sanitation.*

The other important mortality differential in this period was that among social classes. Mortality statistics by social class are not collected in Sri Lanka; however, some estimate of the extent of social class differentials can be gauged by surveying the extent of differences by ethnic groups, since certain ethnic groups in certain localities work in specific occupations which can be categorized according to some social class gradation. For instance, the majority of Moors, Malays and Tamils* in Colombo in the early decades of the century were engaged in labouring occupations and their mortality levels are an indicator of mortality among the urban poor. On the other hand, the Burgher and Eurasian populations in the main held professional and middle-level jobs, the majority being clerks, railway employees, teachers and higher professionals; the censuses do not enumerate any of them as labourers. Their mortality levels would seem to provide some index of mortality among the middle classes in the country. Similarly, statistics of mortality among Tamils in the plantation districts refer in the main (over 95 per cent) to plantation labour.

If the level among the Burgher population is taken as a standard representing mortality among the middle classes, comparison with levels prevailing among other

* However, such a conclusion may not be correct in regard to infant mortality, where the prime factor could have been better midwifery services.

* Among the Tamils it was mainly the Indian Tamils who belonged to the labouring poor. However, the Registrar General's statistics include the Ceylon Tamils and the Indian Tamils under one category, the "Tamils". The rate calculated from this aggregate data underestimates the mortality of the urban poor, since a large number of the Ceylon Tamils in Colombo belonged to the middle and upper classes.

TABLE 5. AGE-SPECIFIC DEATH RATE PER 1,000 POPULATION IN A DEVELOPED ZONE (KALUTARA DISTRICT): SINHALESE POPULATION, 1920-1922 AND 1944-1946

Age group	*Male*			*Female*		
	1920-1922	*1944-1946*	*1944-1946 / 1920-1922 (%)*	*1920-1922*	*1944-1946*	*1944-1946 / 1920-1922 (%)*
0-1	114.3	96.0	84	101.1	80.6	80
1-4	31.1	20.7	67	41.8	28.7	67
5-14	8.2	4.5	55	10.1	3.2	32
15-24	7.0	4.2	60	8.4	4.9	58
25-34	8.7	5.6	64	11.2	7.1	63
35-44	10.3	6.8	66	11.9	7.0	59
45-54	17.6	11.2	64	12.9	9.8	76
55-64	29.3	22.0	75	28.0	17.8	64
65+	108.6	90.6	83	120.1	88.1	73
All	20.6	15.2	74	21.9	15.1	69

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1920 to 1922 and 1944 to 1946 and from the 1921 and 1945 censuses of Ceylon.

TABLE 6. AGE-SPECIFIC DEATH RATE PER 1,000 POPULATION IN A DRY ZONE (NORTH CENTRAL PROVINCE): SINHALESE POPULATION, 1920-1922 AND 1944-1946

Age group	*Male*			*Female*		
	1920-1922	*1944-1946*	*1944-1946 / 1920-1922 (%)*	*1920-1922*	*1944-1946*	*1944-1946 / 1920-1922 (%)*
0-1	335.3	229.4	68	306.5	224.6	73
1-4	55.0	40.0	73	66.1	46.9	71
5-14	13.4	7.5	56	13.6	9.6	71
15-24	14.9	10.2	69	27.1	22.4	83
25-34	23.2	14.9	64	31.0	24.8	80
35-44	29.8	22.7	76	33.7	25.0	74
45-54	46.5	34.3	74	46.4	35.1	76
55-64	63.4	52.2	82	83.2	55.5	67
65+	181.1	125.5	69	195.1	119.6	61
All	42.1	28.0	67	48.1	34.7	72

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1920 to 1922 and 1944 to 1946 and from the 1921 and 1945 censuses of Ceylon.

groups of the population in the period 1920-1922 indicate in general the following (tables 7 and 8):

(*a*) Infant and child mortality among the middle classes was much lower than among most other groups; however, rural infant mortality in the non-malarial areas was lower still;

(*b*) There were significant differentials in infant and child mortality even between rural non-malarial districts;

(*c*) There were no significant differentials in male adult mortality between social classes except among the urban poor, whose mortality was much higher;

(*d*) Mortality among middle-class females of all age groups was generally lower than that of females in poorer groups;

(*e*) Mortality among the urban poor for both sexes was higher (for some age groups nearly double) than that among the middle classes;

(*f*) Except among infants, mortality among males for all social groups was in general lower than that of females for corresponding age groups.

B. Famines, nutrition and mortality

As is well known, subsistence crises which are characteristic of pre-industrial economies lead to sharp rises in mortality. Such crises were common in the nineteenth century in Sri Lanka. The demographic details of the impact of famines are lacking for early periods because of the absence of reliable vital registration. Further, even though vital records are available for later periods, they relate only to administrative divisions and not to social classes. Thus, although malnutrition, and during some seasons and years starvation, was a recurrent phenomenon among certain groups such as agricultural labourers, vital records can rarely be used to examine the impact of such conditions on mortality. However, the devastating effects of famine and food shortages on mortality are clearly illustrated by the events of 1974 in the estate sector in Sri Lanka. High prices and food shortages caused by successive droughts in Sri Lanka and abroad and the world-wide inflation had an immediate impact on the nutritional levels of those groups among the poorer

TABLE 7. AGE-SPECIFIC MORTALITY PER 1,000 OF THE POPULATION AMONG DIFFERENT SOCIAL GROUPS IN 1920-1922, MALES

Age group	*Tamils, Moors and Malays in Colombo (Urban poor)*	*Tamils in Nuwara Eliya district (Plantation workers)*	*Burghers and Eurasians in Sri Lanka (Middle class)*	*Sinhalese in Nuwara Eliya district (non-malarial area) (Rural villager)*	*Sinhalese in Kalutara district (non-malarial area) (Rural villager)*
0-1	341	248	158	173	114
1-4	68.0	60.1	26.7	48.8	31.1
5-14	8.9	10.6	6.3	9.7	8.2
15-24	12.8	7.8	7.2	6.3	7.0
25-34	11.8	9.0	9.4	4.8	8.7
35-44	18.2	11.0	12.5	12.9	10.3
45-54	26.4	22.0	22.5	18.9	17.6
55-64	43.9	45.6	49.2	30.7	29.3
65+	139.0	258.4	116.6	125.3	108.6
All	226.0	229.5	22.1	20.3	20.6

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1920 to 1922 and from the 1921 census of Ceylon.

TABLE 8. AGE-SPECIFIC MORTALITY PER 1,000 OF THE POPULATION AMONG DIFFERENT SOCIAL GROUPS IN 1920-1922, FEMALES

Age group	*Tamils, Moors and Malays in Colombo (Urban poor)*	*Tamils in Nuwara Eliya district (Plantation workers)*	*Burghers and Eurasians in Sri Lanka (Middle class)*	*Sinhalese in Nuwara Eliya district (non-malarial area) (Rural villager)*	*Sinhalese in Kalutara district (non-malarial area) (Rural villager)*
0-1	320	210	144	151	101
1-4	78.3	61.1	34.3	52.6	41.8
5-14	10.9	13.8	5.6	12.7	10.1
15-24	20.2	10.6	7.1	11.0	8.4
25-34	25.3	15.1	11.0	13.5	11.2
35-44	25.6	21.9	14.7	12.5	11.9
45-54	32.0	24.8	14.3	17.6	12,9
55-64	43.6	54.7	33.0	41.5	28.0
65+	225.0	313.6	87.1	181.7	120.1
All	41.7	32.7	19.9	30.0	21.9

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1920 to 1922 and from the 1921 census of Ceylon.

classes who were not producers of food. In Sri Lanka these are the tea and rubber estate workers and the landless peasants as well as the labouring classes in the towns. The estate workers, although formally a part of the agricultural sector, do not produce any staple food items; they, like the urban workers and the urban poor, are part of the monetized sector of the economy and feel the impact of such a crisis. Of these seriously affected groups, only the estate workers are represented in the Registrar General's statistics as a separate group.

The estate mortality figures for 1974 provide a broad indication of the havoc wrought by the crisis (see table 9). The food crisis seems to have increased mortality sharply in almost all age groups, indicative of what must have been a common situation in Sri Lanka during the nineteenth century. The increase was especially high among male adults in the group aged 35 to 64. Children aged 1 to 4 seem to have been less affected by the famine. Also, among adults, females seem to have been much less affected by the food shortage than males. The much lower increase in death rates among estate children and adult females could reflect the fact that their mortality rates were high even in normal years relative to the rest of the population.

TABLE 9. COMPARISON OF AGE-SPECIFIC MORTALITY RATES PER 1,000 POPULATION IN THE FAMINE YEAR (1974) AND IN A NORMAL YEAR (1973), THE ESTATE SECTOR OF SRI LANKA

Age group	Males			Females		
	Normal year 1973	Famine year 1974	Percentage increase	Normal year 1973	Famine year 1974	Percentage increase
0-1	114	171	50	92	154	67
1-4	8.1	10.4	28	9.6	12.4	29
5-14	1.8	2.5	39	2.0	3.3	65
15-34	1.9	3.4	79	3.0	3.3	10
35-44	3.3	8.6	161	5.3	7.7	45
45-54	7.4	15.6	111	9.6	14.4	50
55-64	16.8	36.8	119	20.4	33.7	65
65+	130.8	258.6	98	148.5	241.0	62

Source: Computed from unpublished data of the Department of Census and Statistics, Sri Lanka.

Although the infant death rate increased sharply during the famine year, the effect of food shortages on infants of different age groups differed markedly (see table 10). On the estates neonatal mortality was hardly affected by the famine, while post-neonatal mortality rose by over 150 per cent. Even in the rest of the country post-neonatal mortality rose by over 30 per cent in the crisis year.

TABLE 10. NEONATAL AND POST-NEONATAL MORTALITY PER 1,000 LIVE BIRTHS IN THE ESTATE SECTOR AND IN THE REST OF SRI LANKA, 1972-1976

Year	Neonatal mortality		Post-neonatal mortality	
	Estate sector	Rest of the country	Estate sector	Rest of the country
1972	67	25	30	17
1973	65	25	32	17
1974	69	19	86	23
1975	57	21	40	20
1976	60	22	41	17

Source: Computed from unpublished data provided by the Department of Census and Statistics, Sri Lanka.

The colonial transformation of Sri Lanka in the mid-nineteenth century from a subsistence economy to one based on plantation crops (mainly coffee, tea and coconuts) for export had important effects on the health of the people. The expropriation of peasant lands for plantation agriculture led initially to the pauperization of many peasant families. However, the long-term impact of these developments was that foreign exchange earnings of the plantation industry made it possible for the country to import a stable and increasing supply of food (see table 11). Famine became extremely rare owing to the availability of imported rice. The increasing availability of stable supplies of food seems to be the key to understanding the lowering of mortality levels in the nineteenth century. Whether the mortality transition actually was associated with the development of a cash crop economy in the nineteenth century cannot be directly addressed, for reliable mortality data are available only from about 1900. However, rubber, one of the major cash crops, was introduced into Ceylon only after 1900 and its effects can be monitored. (Rubber now is the main cash crop in the Kalutara, Kegalle and Ratnapura districts of Sri Lanka.)* The most backward of these districts during this period was the Ratnapura district, and it is here that the impact of rubber growing is best investigated. In Ratnapura, rubber planting began in 1905 and was well productive by 1920.

The growth of cash crops such as rubber had a twofold effect on peasant society. First, even though much

TABLE 11. SELECTED FOOD IMPORTS TO CEYLON, 1870-1932
(*cwt per million population*)

Year	Rice	Potatoes	Dried fish	Sugar
1870-1872	1 141 060	3 919	33 959	6 005
1880-1882	1 234 100	6 399	33 172	7 772
1890-1892	n.a.	11 729	60 775	19 829
1900-1902	1 488 409	23 920	77 352	52 223
1920-1922	1 397 194	22 494	76 195	95 503
1930-1932	1 685 321	41 832	75 548	249 859

Source: Ceylon "Blue books".

* Even in these areas, either the cultivation of coconuts, cinnamon or the mining of plumbago or gems had led to some monetization of the economy during the nineteenth century.

of the rubber was grown in estates manned by immigrant labour, it still provided some employment to the lower stratum of village society, acting as a buffer during a period of crop failure. The extension of the plantation system into a district had a multiplier effect on economic activity, especially in trade, construction and road works, all of which provided employment to villagers.

Second, the growth of small holdings of export crops among the more prosperous villagers made possible a general increase in the level of living. Thus, at the household level the effect of these changes was to provide the cash to purchase food to supplement domestic production during a normal year as well as adequate means to purchase bare necessities during crises caused by drought. The position in two divisions of Ratnapura, the Nawadun and Kuruwita Korales, was well described by a government agent in 1913 after a failure of the southwest monsoon. which had destroyed the paddy crop.

> "Fortunately, however, in the Kuruwita and Nawadun Korales, where the effects would likely be felt most, the majority of the population do not look to paddy and chena cultivation as the sole means of livelihood. In these Korales there is a growing tendency to abandon paddy cultivation for work on estates. Work on estates is ultimately not so remunerative to the villager as paddy and chena cultivation, which usually supply him with all his requirements, but the regular payment of wages has the advantage of providing the villager with the ready means of purchasing articles of food and of giving him more opportunities of leading a leisurely life. Therefore, so long as the estates continue to prosper, there is no likelihood of the occurrence of any distress." (Ceylon, 1914, p. 2)

The effect on mortality levels of stable food supplies and the modernization implicit in the introduction of a commercial sector is seen in the declining trend of the death rate of the Sinhalese* in the Nawadun Korale (table 12).

The death rate, which had been ranging between 30 and 40, came down to around 20 after 1920. One reason for this decline was that previously the effect of malaria epidemics had been aggravated by the general debility of the population, who had to face periodic crop failures. Also, even in non-malarial years endemic malnutrition carried off a large number, particularly among the young and the aged, by aggravating the effects of other diseases such as pneumonia and dysentery. With the availability of imported food, nutritional levels improved, and the destructive effects of epidemics were lessened.

The influence of famine on diseases other than malaria has been commented upon by other observers. Heckscher, writing of eighteenth-century Sweden, comments on the increase of these diseases during a famine:

> "The Danish statistician, Adolph Jensen, has pointed out a feature with regard to deaths from contagious diseases which seem to corroborate this conclusion, i.e. he points out that deaths from these ever present diseases rose and fell inversely with the crops. This seems to prove that, when the poor had been weakened by an unusual scarcity of food, they fell an easier prey to contagious diseases." (Heckscher, 1950, p. 271)

Because of the presence of the malarial factor in Sri Lanka, it is difficult to document statistically the increase in mortality from typhoid and diarrhoeal diseases during and after a famine. However, there is some evidence to support the view of an increase in these diseases. The district of Galle is free from malaria and rarely suffered from famine because it was dependent on cash crops in exchange for which it could purchase imported food. In 1920 a trade depression in the tea, rubber and plumbago markets, which were the mainstay of the economy of this district, coincided with a failure of crops in the overseas regions from which the country imported its food. This led to great distress in the district. The allotment of rice for the district

> ". . . was wholly inadequate, and sank at one time to as low as half a measure per week per head of the population. A quarter measure is the quantity which gives a square meal; the poorest had long been accustomed to at least one meal of rice a day and did not take kindly to substitutes. Great scarcity reigned in every house and as the people could not or would not believe that the supply to the district was so small there was much dissatisfaction." (Ceylon, 1921, p. 2)

The extent of the rise in mortality levels during the crisis of 1920 is concealed by the high figures for 1918 and 1919 resulting from the influenza epidemic. But the serious nature of the impact such famines have on mortality levels is seen in the death rate for 1920, when mortality was higher than even during the influenza epidemic (table 13). It is also interesting that during this crisis in

TABLE 12. CRUDE DEATH RATE PER 1,000 OF THE SINHALESE IN THE NAWADUN KORALE, 1901-1930

Year	*Death rate*
1901-1905	32.0
1906-1910	38.8
1911-1915	32.8
1916-1920	29.0
1921-1925	21.2
1926-1930	21.0

Source: Reports of the Registrar General of Ceylon on vital statistics for the years 1901 to 1930. Period figures are simple averages of annual rates.

NOTE: The real decline was even sharper, for death registration was gradually improving during the period.

TABLE 13. CRUDE DEATH RATE PER 1,000 POPULATION, GALLE DISTRICT (INCLUDING MUNICIPALITY), 1911-1925

Year	*Death rate*	*Year*	*Death rate*	
1911	26.4	1918	28.9	Influenza epidemic
1912	27.7	1919	30.1	
1913	28.9	1920	32.2	
1914	28.4	1921	27.8	
1915	23.8	1922	23.0	
1916	25.1	1923	25.4	
1917	26.2	1924	22.8	
		1925	22.7	

Source: Reports of the Registrar General of Ceylon on vital statistics for the years 1911 to 1925.

* The indigenous peasantry of this region are Sinhalese, and the trend in their death rate gives an indication of the pattern of demographic transition which came about with the new economy.

the district "enteric fever appeared all along the coast and in some interior villages. . . . Dysentery was also very prevalent and chicken-pox appeared sporadically". (Ceylon, 1921, p. 2)

C. Cholera epidemics and factors affecting their reduced frequency

The statistics of cholera cases and deaths (see table 14) indicate that after a period in which cholera attacked on a large scale there followed, from the decades after 1880, a drastic reduction in the prevalence of the disease.

Table 14. Cholera in Ceylon, 1841-1950

Years	No. of cases	No. of deaths	Fatality rate (%)
1841-1850	16 869	10 296	61
1851-1860	35 811	24 254	68
1861-1870	30 324	18 523	61
1871-1880	36 756	19 960	54
1881-1890	3 868	2 452	63
1891-1900	6 127	3 765	62
1901-1911	1 718	1 064	62
1912-1920	1 104	763	69
1921-1930	424	280	66
1931-1940	94	79	84
1941-1950	242	164	68

Source: The figures for the number of cases and deaths are from the administrative report of the Director, Quarantine Department, 1951 (Colombo, 1952).

Before the 1880s, the death toll from the disease was very heavy. In the epidemic of 1866-1867 the death rate from cholera rose to as high as 25 to 30 per 1,000 population.* A similar outbreak occurred in 1876-1877. But after the 1880s, although there were almost yearly outbreaks of cholera in the island, epidemics were much less severe and the numbers of cholera deaths were not significant in influencing the level of mortality in the country.

The number of deaths from cholera decreased because of a sharp reduction in prevalence. Fatality remained stable, indicating that the disease had not become less virulent and that any medical treatment given had not significantly altered the lethality of the disease over the years. It is worth noting that in India, the source of the disease, the toll was no smaller after 1880.

Given this background of continued virulence there were three complementary approaches to combat mortality from cholera:

(*a*) As the disease was never endemic in Ceylon, the first step was to prevent its entry into the country through improvement in quarantine procedures;

(*b*) Once cholera had entered the country, it was important to limit the duration and spread of an epidemic by isolating patients and contacts, disinfecting contaminated articles and, if necessary, burning contaminated belongings and unsanitary dwellings. This led to the creation of a public health department and legislation to give it the necessary powers of enforcement;

(*c*) Efforts were necessary to reduce the explosive nature of epidemics in densely populated areas by improving sanitation and providing uncontaminated drinking water supplies. This intervention is considered below in conjunction with activities directed against typhoid.

The development of a quarantine system

Cholera was never endemic in Ceylon but brought in by immigrants from India, called coolies, who worked on the plantation estates. The crux of the problem of control was to prevent potential immigrants stricken with the disease from entering the country. During early years, however, measures taken to control their entry were almost totally ineffective.

The immigrant labourers entered the island either through Mannar on the north-west coast of Northern Province or through Colombo. From Mannar, they were marched along the Great North Road to the centre of the island, in which the estates were sited. During the nineteenth century, quarantine arrangements on this route were very deficient. Under the prevailing system of quarantine at Mannar,

> ". . . the coolies are examined on arrival and departure, and ships with any sickness on board are obliged to hoist a yellow flag and land the sick separately. There is not much sickness on their arrival or departure, but very much on the road, as soon as they commence their journey, the sickness which is in the system breaks out." (Ceylon, 1867)

Those falling ill at the wayside communicated the disease among the local population in the Northern Province, thus negating quarantine arrangements.

> "A number of coast people and others keeping boutiques along the road who, immediately they get any sickness, go off into the villages in the country and carry the contagion with them. Then again the road is open to traffic of all kinds along its length, and all these merchants mix with people along the road." (Ceylon, 1867, p. 90)

The Principal Civil Medical Officer of the colony commented in 1875

> ". . . on how futile all efforts at keeping the country free of infectious disease by means of quarantine must ever be, for here actually no cases had occurred at the port of entrance into the island, and still apparently healthy coolies fell ill on the first or second day after arrival, and they could not contract the disease in the north of the country for it was perfectly free from cholera until introduced by immigrants." (Ceylon, 1876, p. 66)

At the port of Colombo, the other principal point of entry for Indian immigrants, every ship carrying a cholera patient had, at least nominally, to be quarantined. But a favourite ruse adopted by ships to evade these arrangements is mentioned,

> ". . . bodies of cholera patients being thrown overboard from native crafts during the voyage, and no report made on arrival here, their bodies having been subsequently washed on shore at Colombo, and after careful post mortem examination, the disease they died from was identified as genuine cholera." (Ceylon, 1877, p. 124).

* The population in the infected villages is given as 295,819, while the number of cholera deaths from January 1866 to March 1867 was 10,210.

Also, although all coolies entering the country through Colombo had to undergo some form of medical check and a short period of quarantine if they had been in a vessel in which there were infected persons, even these measures were valueless, as many of the coolies came in disguised as traders. As the Principal Civil Medical Officer commented in 1877:

"From the . . . figures it cannot be doubted that many of the so-called native traders were simply coolies disguised so as to evade our quarantine regulations, and this fact will in a great measure explain the failure of our well devised precautions to protect the country from epidemic disease, for, against my advice, entry without detention was allowed to traders if free from disease, while the coolies were subject to quarantine." (Ceylon, 1878, p. 216)

Thus, even though in theory quarantine arrangements existed, in fact they were applied in such a manner as to make them useless. As the same Officer commented:

"In my opinion, the failure of quarantine is due to the partial manner in which it has been applied, and to the dishonesty with which officers in charge of vessels strive to conceal all evidence of disease that may have occurred during the voyage, the conflicting interests of commerce with the public health render quarantine regulations inoperative." (Ceylon, 1878, p. 214)

But problems associated with entry without proper quarantine came to a head in 1896 with the outbreak of plague in India. The consequent panic in Ceylon and the fear that the "appearance of the disease in Ceylon would assuredly lead to the prohibition of the introduction of Ceylon produce and exports into Europe" (Ceylon, 1897, p. 1) led to certain important developments. In 1899, entry through Mannar was stopped and Colombo was made the only official port of entry from India. In addition, the Quarantine and Prevention of Diseases Ordinance No. 3 of 1897 was enacted, and regulations were framed for the segregation and quarantine of immigrants from India at Ragama Camp a few miles outside Colombo. The passage of immigrants through Colombo was brought to an end in 1917 with the opening of the Indo-Ceylon railway, and a quarantine camp was built at Mandapan in India in 1917 to deal with these passengers. It is difficult to assess the value of these measures but the number of cholera deaths in the decades following the 1897 and 1899 measures and the 1917 measure were only about 30 per cent and 40 per cent respectively of the previous decade (see table 14). The continued occurrence of cholera even at a low level was a sign that the quarantine measures were only partially successful. Success was only partial because of the difficulties faced by the camp authorities when,

". . . with hundreds of coolies arriving from India daily it would be impossible to quarantine all of them for the five days for cholera and 18 days for smallpox, which are the incubation periods respectively . . ." (Ceylon, 1907, p. 3)

and, as Benenson has noted,

". . . failure of quarantine measures was predicted 100 years ago on the basis that those most likely to carry the organism would probably not be so considerate as to report to quarantine stations. Experience has borne this out in that many introductions of disease into clean areas have been attributed to smugglers, fishermen or others who cross borders at undesignated points. Among those who do properly pass through the quarantine station, vaccine will not assure that the traveller is not a carrier and it will not guarantee that the individual may not develop clinical disease. Even when excessive measures have been applied by some countries, a rectal swab and a requirement for a negative culture will not detect the individuals whose gall bladders and duodena contain cholera vibrios which, under appropriate conditions can transit the intestinal tract." (Benenson, 1971, pp. 1206-1207)

Nevertheless, as the figures in table 14 illustrate, even the partially successful quarantine procedure acted as a safety net, eliminating the obvious cases of cholera, and limiting the number of cholera outbreaks, which would have otherwise been higher.*

The control of epidemics and the development of public health services

The gradual decrease in the number of victims claimed by cholera was also a result of an improvement in techniques for limiting an outbreak and bringing it under control. When cholera appeared, fear often led to panic among the population, resulting in a worsened situation. For example, when cholera broke out among some immigrants on an estate in Uva Province in 1906, the labourers from local villages who contracted it panicked and fled, spreading the disease to all the neighbouring villages and hindering the isolation of cholera contacts. Officials were also thwarted by people who, with justification, feared being quarantined in hospitals and camps. In 1889, the Government Agent of the Western Province voiced the difficulties faced by officials in limiting the course of an epidemic.

"The people will not give information of the cases, because they are afraid of being taken to hospital and because they prefer native practice. To prosecute is impossible, unless there were an isolated court and prison." (Ceylon, 1890, p. 22)

It was not simply that cases of cholera were concealed. There was great prejudice against necessary sanitary measures. During an outbreak of cholera in the Trincomalee district in 1891,

"Many of the Vellalas, who form the most influential class here, formed a secret combination to work up the poorer and more ignorant classes to oppose sanitation in every way. Finding our patience inexhaustible and the good sense of the lower classes successfully combating their conspiracy, they finally employed the most ignorant of their own class, Tanakarars, with hired ruffians from Jaffna to assault the officials. Notwithstanding this, we continued our

* That quarantine acted as a limited barrier is also illustrated by the fact that cholera broke out periodically in quarantine camps. In 1900, there were 11 distinct outbreaks of cholera among Indian immigrants at the Ragama quarantine camp; if there had not been such a camp, such persons would have travelled freely about the country and it is highly probable that this would have led to more cholera outbreaks in the country. Even more conclusive proof of the value of quarantine was shown in 1917, when there was no cholera outbreak in Ceylon, even though at Mandapan, the quarantine camp at the point of entry, 26 cases of cholera and 8 deaths were recorded during the year.

efforts and towards the close of the epidemic the prejudice of all but the influential conspirators had been broken down." (Ceylon, 1892, p. 11)

In spite of these difficulties, the Medical Department, by their prompt response to the news of an outbreak of cholera, were successful in limiting the course of the disease. The specific successful measures can be listed as follows (Ceylon, 1892, pp. 40-43):

(*a*) Cordons were placed round the infected area, which was strictly guarded by police constables, and all traffic suspended with the infected area;

(*b*) Every infected house was kept under police guard to prevent contacts;

(*c*) After the death of a patient all inmates were removed to a house of refuge;

(*d*) Preparations for burial were made as soon after death as possible, and a constable invariably accompanied the burial party both there and back along a certain prescribed route and saw to it that the grave was of a sufficient depth;

(*e*) Disinfection was done of houses and of all articles of furniture and clothing;

(*f*) The dwelling was kept closed for five days before people were allowed to return;

(*g*) Gardens were scavenged and all rubbish burned; and the latrines, where such existed, were disinfected with sulphate of iron and carbolic acid;

(*h*) Fresh water was supplied in casks to all infected houses.

Wherever these measures were systematically carried out the disease was halted, as in Trincomalee where in 1891 cholera was curbed on its appearance and there were only 12 cases. When these measures were not fully carried out, cholera continued to appear. For example, when an epidemic broke out in another quarter of Trincomalee among the poorer classes, opposition and riots made preventive measures impossible and 341 deaths resulted.

The legal position of the officials during an epidemic was difficult, and one of them pointed out in 1891 the need for

"... amending the present Contagious Diseases Ordinance No. 8 of 1886, or at least the present system, whereby a special proclamation has to be issued on the occurrence of each outbreak in each province. The English Infectious Diseases (Prevention) Act of 1880 and the Public Health (London) Act of 1891 give the necessary powers permanently and thus the necessary steps for removal, isolation and disinfection can be legally taken with regard to the first and subsequent cases of any epidemic, and thus the spread of the epidemic can be limited. In Ceylon, these cannot be taken legally till the proclamation is printed in the Gazette. It seems strange that this anomaly of locking the door after the infection has been allowed to spread still remains in Ceylon." (Ceylon, 1891)

Dr. Aserappa, Sanitary Officer of Colombo, referred to the difficulties faced by officers in isolating contacts, since it has been "held by some magistrates that to charge a person with resistance, he must have used some violence or done some distinct act to prevent carrying out the order." (Ceylon, 1891)

These defects were remedied by the previously mentioned 1897 ordinance, but legislative enactments alone could not suddenly produce effective measures to restrict the scope of an epidemic. In 1900, 1906, 1910-1911, 1919 and 1925 there were cholera epidemics on a fairly large scale, and such outbreaks were ultimately stopped only with the slow development of public health services. Cholera continued to be a source of irritation to the health authorities, who had to be continually vigilant in order to keep under control the outbreaks which occurred almost every year till the late 1940s.

The gradual improvement in the methods of controlling epidemics can to some extent be assessed statistically. Table 15 gives statistics during cholera years regarding the number of towns, villages or estates where cholera appeared.*

TABLE 15. NUMBER OF CHOLERA CENTRES AND CASES IN CEYLON DURING CHOLERA YEARS, 1891-1946

Year	*Centres*	*Cases*
1891	198	2 579
1892	90	1 712
1894	16	75
1895	31	156
1896	2	138
1897	14	216
1898	67	426
1900	104	814
1901	10	152
1902	32	179
1906	50	756
1925	33	305
1926	12	56
1935	2	30
1936	9	49
1942	2	65
1943	5	63
1946	4	74

Source: Ceylon, Administration reports of the Immigration, Quarantine and Medical Departments.

NOTE: Figures on cholera centres are not available for the period before 1891.

The figures show a reduction in the number of centres where cholera appeared only after 1925, indicating that success of the public health department in localizing outbreaks did not occur immediately upon the passage of the 1897 ordinance. Eventually during epidemic years the disease was restricted to a few villages in a district or, at the most, confined within the boundaries of a province. So, for example, in 1935, the disease was restricted to Colombo and its environs, in 1936 to a few villages in the Eastern Province and in 1942 to the North Central Province. This was in contrast to the earlier situation where, even though there was much less travel, epidemics generally spread across provincial boundaries.

* Table 15 should be interpreted with care, since it refers to towns, villages and estates in which cholera appeared, and not to the different outbreaks during the year in the island. Thus, for example, in 1936, although nine villages were affected by cholera and statistics indicate nine cholera centres, the Director of Medical and Sanitary Services commented that there were only two distinct outbreaks, both of which were confined to the Eastern Province. See Administrative Report of the Director of Medical and Sanitary Services, 1936 (Colombo, 1937), p. 5.

Medical care and its impact

Finally, the effect of medical care on reducing mortality from cholera in Ceylon is of some interest. The fatality rates in table 14 do not indicate an increase in the proportion cured over the years. This is not surprising, since treatment was restricted to isolation in temporary cholera hospitals which were in fact quarantine camps. The very few who were admitted to hospitals did not have the benefit of modern treatment, such as hydrotherapy, and even as late as 1935, there were 22 deaths among the 30 cholera cases warded.

The number admitted to hospitals was generally low, so that medical treatment and care was not an important element in the campaign against cholera. Even among those cholera patients who were admitted, the fatality rate, as table 16 indicates, was not significantly different than among those who did not have the benefit of hospital treatment. The very high mortality in hospitals was, of course, not surprising, since treatment by rehydration was not then available.

TABLE 16. FATALITY RATES OF CHOLERA CASES, 1891-1936
(*Percentage*)

Year	*Admitted to hospital*	*Not admitted to hospital*
1891	53	60
1898	44	76
1900	74	56
1906	100[a]	59
1926	83	86
1935	73	All cases were admitted
1936	50[a]	91

Source: Ceylon, Administration reports of the Medical Department.

[a] Only two cases were admitted in each of these years.

In summary, the history of cholera in Ceylon indicates that quarantine, whatever its drawbacks, was one of the major instruments of cholera control. This was particularly so since cholera was not endemic in Ceylon but imported mainly from zones with endemic cholera in India. But quarantine alone would have been a failure; it was the slow but steady development of public health services, and their vigilance, which succeeded first in restricting the scope of the disease when it had escaped the quarantine net and ultimately stamped it out wherever it appeared, that made cholera in Ceylon a disease no longer to be feared.

D. POPULATION DENSITY, WATER AND SANITATION, AND MORTALITY: EXAMPLES OF COLOMBO AND THE ESTATES

Mortality and urban growth in Colombo

Although figures on mortality are not available for the nineteenth century, evidence seems to indicate that at the beginning of the nineteenth century Colombo was a relatively healthy city with between 20,000 and 30,000 people. For example, one knowledgeable observer wrote in 1807, about the experience of British soldiers, that

> "No climate in the world is more salubrious than Colombo, and a person who remains within doors while the sun is powerful, never wishes to experience one more temperate. During 5 years residence there I rarely heard of any person being sick, unless those whose illness was caught in the interior of the country . . . a funeral was not a common occurrence at Colombo and out of a 1,000 British soldiers, it often happened that one man was not lost in the space of two months." (Cordiner, 1807, p. 61)

However, conditions deteriorated during the second half of the nineteenth century, at which time the growth of an export-import economy based on the plantation agriculture of coffee, tea and rubber led to the growth of Colombo as a centre of shipping, trading and administration.

Due to these developments, the pace of growth of Colombo quickened in the last part of the nineteenth century and again during the first decades of this century (see table 17). The expansion was attended by the growth of a large poor quarter where the labouring classes were concentrated on which the city depended for the handling of its export-import trade as well as for the other services needed in urban centres. The impact of this quarter on the health of the city was disastrous, especially since many of the poorer households did not have access to pipe-borne water supplies. The wells from which drinking water was obtained were polluted by the cesspits which abounded in the city in the absence of a pipe-borne sewage scheme. The result was that typhoid and diarrhoeal diseases were rampant in the city, while periodically the cholera carried by traders and labourers from India spread in explosive epidemics through water drunk from contaminated wells.

TABLE 17. POPULATION OF COLOMBO, 1824-1946

Census year	*Population*	*Average annual exponential intercensal growth rate*
1824	32 288	2.4
1871	99 787	1.5
1881	116 441	1.4
1891	134 366	2.2
1901	167 677	2.7
1911	220 648	1.2
1921	248 826	1.3
1931	284 155	1.6
1946	362 074	-

Source: Censuses of Ceylon.

With the growth of a large poor quarter, not only was the health of those residing there affected, but also contagious diseases spread due to

> ". . . constant communication between the quarters of the poor and those of the well to do, through servants, tradesmen, etc. many of the diseases which are bred and fostered in the poorer quarters of the city, e.g. enteric, phthisis, etc. cannot be restrained within such limits." (Ceylon, 1912)

The poorer quarters of the city, where the main foci of the disease were located, contributed most to the high mortality in the city. The standard of housing and sanitation in the poorer areas in the 1880s can be gauged from the following report by the city's first Medical Officer:

> "In these courtyards one frequently sees a dilapidated well with as bad a privy not many feet distant

from it. Here, too, are cattle in the shape of cows, goats and pigs. Water is drawn out of the well for drinking purposes by the denizens of these rookeries by means of all manner of dirty vessels attached to strings or bits of rope equally filthy. Bathing, washing of the foulest clothes, and watering of cattle are all carried on at the well, the protecting walls of which reveal several gaps from the falling out of stones with which they were originally built. To complete the picture, children in a state of nudity are seen dotting the yard with human ordure." (Ceylon, 1907, p. 25)

One of the problems of sanitation in the city at the turn of the century was that the lavatories of the houses were mainly permeable cesspits through which liquid waste matter could percolate into the soil and thus into the wells which were sited in the neighbourhood. This pollution of the soil and of the water was one factor responsible for the large number of epidemics in Colombo. The first step of municipal medical officers to attack these problems was the provision of a pipe-borne pure water supply to Colombo in 1887. The results were almost immediate, for the Principal Civil Medical Officer of the colony remarked in 1893 that typhoid fever had almost disappeared from Colombo.

Nevertheless, within a few years the influx of people into Colombo was such that the water supply was not sufficient to meet demand, so once again sections of the population were forced to use well water. Even in 1905 there were still 2,119 wells in Colombo, and a survey during the period of 1903-1905 of 510 of these found that three quarters of them had contaminated water and needed to be condemned (Ceylon, 1907, p. 25). The Medical Officer of Colombo commented in 1912:

"All the wells in Colombo are technically 'shallow' wells and when one considers the foul nature of the soil in which a large proportion of them are sunk, it is not surprising that out of 66 samples examined chemically during the year, 51 or 77% were condemned as unfit for human consumption. Unfortunately for them the people in their ignorance cling to these foul wells which they like owing to the coolness and clearness of the water which they contain, and one cannot convince them that the most dangerous of waters are often very bright, sparkling and pleasant tasting." (Ceylon, 1914)

The period after 1900 saw a systematic inspection of wells, and those with contaminated water were condemned and closed.

The other step taken in the direction of improved sanitation was the gradual closure of the cesspits and their replacement by dry earth privies. This was done rapidly in the first decade of this century, as shown in table 18, although a few cesspits continued to remain as a source of infection in the compounds of the poorer classes of the population.

TABLE 18. NUMBER OF CESSPITS IN COLOMBO, 1896-1927

Year	*Number*
1896	4 653
1905	1 837
1919	580
1920	555
1921	319
1925	139
1927	100

Source: Ceylon, Administration reports of the Municipal Council of Colombo.

What impact did these measures have on mortality rates in Colombo? Due to the heavy migration into the city, reliable estimates of mortality can be made only for census years, and because of the marked under-registration of deaths, mortality statistics for the census years before 1901 are not reliable. However, the overall declining trend in mortality in Colombo during the succeeding years can be seen from table 19.

TABLE 19. CRUDE DEATH RATE IN COLOMBO, 1901-1963

Year	*Death rate (excluding non-resident deaths in hospitals)*
1901	32.3 to 35.2
1911	30.9
1921	28.8
1931	18.9
1946	15.8
1953	15.7
1963	8.1

Source: Computed from data in the Administration reports of the Municipal Council of Colombo.

NOTE: Figures of non-resident deaths are not available for 1901; the lower bound to the estimate for tnis year is based on the assumption that the percentage of non-resident deaths in 1901 was the same as in 1911, while the upper bound of the estimate assumes that there were no non-resident deaths in Colombo in 1901. The figures of non-residents who died in the city but outside its hospitals were not excluded, since they were not available separately till 1927. They do not significantly alter the trend in these rates, for even as late as 1927 such deaths constituted only 6.6 per cent of the total deaths (excluding non-residents in hospitals) registered in the city.

Although no measure of mortality is available prior to 1901, it is almost certain that there was a fall in mortality levels in the decade prior, for it is known from the annual reports of the city's Ministry of Health that epidemics of cholera, smallpox, typhoid and various bowel diseases were regular occurrences in the 1870s and 1880s, while in the reports of the period round 1901 comments abound on the improvement in the health of the city after the introduction of a pipe-borne pure water supply and the enforcement of sanitary and quarantine measures. Table 20 indicates the rapid fall in numbers of deaths from cholera during the last decade of the nineteenth century. Thus it would not be wrong to say that the death rate in Colombo had fallen to some extent by 1901.

In the 20 years from 1901 to 1921 the crude death rate declined from a level near 35 per 1,000 population to 28.8 (see table 19), a rather slow rate of decline when it is

TABLE 20. NUMBER OF CHOLERA DEATHS IN COLOMBO, 1867-1926

Year[a]	*Number*
1867-1876	785
1877-1886	737
1887-1896	106
1897-1906	67
1907-1916	119
1917-1926	9

Source: Ceylon, Administration reports of the Principal Civil Medical Officer.

[a] Figures not available for earlier years.

compared with the 10 years from 1921 to 1931 when the crude death rate fell very steeply from 28.8 to 18.9.

The changes in mortality from diarrhoeal diseases in the city during this period provide support to the role of the aforementioned public health factors in causing these mortality changes (see table 21). The filling of cess-pits and their replacement by a bucket system led to an improvement in sanitary conditions which was reflected in the lowering of the mortality rate from diarrhoeal diseases in the period 1901 to 1911, but it did not lead to any fundamental transformation in the conditions leading to the spread of these infections. Thus, even in 1911 the death rate among residents from these diseases was over 4,000 per million of the population. This was because the dry earth privy had certain negative features which prevented any great improvement in sanitary conditions. Namely, the bucket system meant the existence of ideal breeding grounds for flies in nearly every household in the city, a position further accentuated by the siting of the dumping grounds for waste matter near the centres of population. The type of dry earth privy used in the poorer houses and tenements had a great defect in that:

TABLE 21. DEATH RATE PER MILLION IN COLOMBO, 1901-1931

Year	Diarrhoeal diseases[a]: Resident and non-resident	Diarrhoeal diseases[a]: Resident only
1901	6 516	n.a.
1911	5 126	4 539
1921	3 404	n.a.
1931	2 221	1 777

Source: Computed from data in the Administration reports of the Municipal Council of Colombo.

[a] Diarrhoea, enteritis and dysentery.

"It has tried to deal only with the faecal matter and has virtually neglected all consideration of urine . . . it may flow down the steps on to the ground, into which it soaks, or may form a pool of decomposing stinking urine, or it may flow along a drain into one of the numerous open surfaces drains which pass into the harbour, the canal lake or simply on to some piece of ground in the vicinity." (Ceylon, 1907, pp. 9-11)

The position was worsened by the indifference and carelessness of even the most educated and well-to-do householders, about whom the Ministry of Health commented in 1911 that although their own latrines were kept in a sanitary condition,

"In only 5 out of a total of 225 premises visited was it found that any sort of covering was used for the contents of the buckets in the servants' latrines, most of which be it noted are situated within a few paces of the back verandah and of the kitchen house. It is no wonder that when the fly season comes around enteric fever breaks out every now and then and spreads amongst these houses." (Ceylon, 1912, p. 43)

To change this situation, construction was begun of a modern sewage system in the city in 1910. Although at first proceeding at a leisurely pace, work was accelerated by the municipal authorities when they found in 1921 that of approximately 18,000 premises in the city only 1,363 had been connected to the sewage system. From 1921 the municipal authorities used compulsory powers to force recalcitrant houseowners to provide drainage facilities in their houses, and in 1923 a scheme of aided drainage was formulated to help those who had been hitherto unable to join the scheme because of high costs. The tempo of activity in the provision of drainage facilities is seen in table 22.

TABLE 22. TOTAL NUMBER OF PREMISES CONNECTED TO SEWERAGE SCHEME IN COLOMBO, 1911-1931

Year	Number
1911	90
1916	976
1921	1 363
1926	4 044
1929	7 794
1931	10 038

Source: Ceylon, Administration reports of the Municipal Council of Colombo.

NOTE: In 1929, out of a total of approximately 21,800 separately assessed premises, only 7,794, or about one third, had been connected to the sewer system.

The construction of sewers meant that soil pollution was lessened, which in turn meant a further reduction in the spread of infection either through contact with infected soil or through drinking water obtained from polluted wells.

In sum, therefore, the data appear to support the proposition that one of the chief factors causing the fall in the death rate in Colombo in the period 1901-1931 was the fall in the death rate from diarrhoeal diseases consequent upon the rapid extension of the sewage system and the substitution of water carriage latrines for dry earth privies.

Concentration of population and mortality on the estates

Densely settled populations living in poor housing in insanitary conditions not only were found in the growing urban centres but were also a characteristic of life in the coffee, tea and rubber plantations. The plantations contained an immigrant labour force first brought to Ceylon in the 1830s as cheap labour by British planters who found in South India people fleeing from food shortages resulting from drought, over-population and landlessness.

Mortality levels among this population were very high in the nineteenth century, when cholera took a terrible toll of those immigrant labourers. However, even in 1911, when the first reasonably reliable mortality figures on the estates were available, crude death rates were as high as 40 per 1,000 (see table 23).

TABLE 23. CRUDE DEATH RATE PER 1,000 IN THE ESTATE SECTOR, 1911-1946

Year	Deaths per 1,000
1911	40.6
1921	41.9
1931	20.8
1946	16.9

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics and the censuses of Ceylon and the reports of the Controller of Indian Immigrant Labour.

One of the factors that contributed to the prevalence of high mortality was the heavy loss of life from diarrhoeal diseases and from ankylostomiasis. The problem was known even in the 1870s. In 1876 the Medical Inspector of Coffee Estates commented:

"'Faecal diseases', i.e. cholera, dysentery and typhoid fever, are the inevitable concomitants of a neglect to make water supply the first object of the planter's solicitude in building lines for his labourers. Caledonia Estate in Kolonna Korale, in the medical district of Rakwana, was the subject of an epidemic of dysentery last year, which, in spite of every effort of the proprietor and the district surgeon, carried off, in a few months, almost weeks, upwards of 60 persons. This outbreak was subsequently traced to water contamination by the excreta of the coolies in lines higher up the estate, which being remedied, the disease at once ceased." (Ceylon, 1877, p. 5)

The estate population increased steeply in the last decade of the nineteenth century (see table 24), when there was heavy migration from India to work on the tea estates, which were much more labour-intensive than the coffee estates, which had been destroyed by blight.

TABLE 24. POPULATION TRENDS IN THE ESTATE SECTOR, 1871-1946

Census year	*Estate population*	*Annual intercensal exponential growth rate (%)*[a]
1871	123 654	5.1
1881	206 495	2.4
1891	262 262	5.2
1901	441 601	1.5
1911	513 467	1.0
1921	568 850	3.3
1931	790 376	0.5
1946	851 359	–

Source: Censuses of Ceylon.
[a] The high rates for certain intercensal periods are due to heavy immigration from India during boom years in the plantation sector.

In the early years of this century, with the increasing population on the estates, the high level of mortality became a matter for concern. The ravages caused by disease were so great that there were dangers of a labour shortage, since given these problems it became more difficult to attract labourers from India. Matters became so pressing that a committee was appointed in 1910 to inquire into the problem of sanitation on the estates. The inquiry revealed many facts regarding the aetiology of disease among the plantation labourers.

A survey of nearly 2,000 estates inspected by the Medical Department in 1907 revealed that only one had made any arrangements for the collection and disposal of night soil. The result was that the area around the labourers' lines was used as a large outdoor latrine. There was extensive soil pollution in the neighbourhood of the huts and tenements inhabited by the labourers, which was the main reason for the high death rate from ankylostomiasis, for even those patients who were treated and cured were reinfected by walking on polluted soil.

Soil pollution had even more disastrous consequences, for it led to the infection of drinking water on many of the estates. The water was carried along unprotected streams to surface water wells with no protecting walls around them, so that when it rained the infected soil was washed into the streams. As the water was used for cooking and drinking, it became an easy medium for transmitting infection, and dysentery and diarrhoea tended to spread rapidly, taking a heavy toll of life.

The immigrant labourers were treated by the planters as people who had incurably bad sanitary habits which could not be changed by even the most diligent supervision.

This attitude can be seen in the evidence laid before a medical committee set up in 1910 to inquire into sanitary conditions on estates. The minutes of the committee record the following exchange;

"*Question*: You have done nothing in the way of a latrine?

"*Witness*: No, because I think they are not practicable with the coolie. I have heard of other people doing it, but not successfully at all. If you erect a latrine near the coolie lines, a coolie may be working 3 miles away and he won't walk back to use the latrine.

"*Question*: But still speaking generally, they may use it when they get the latrine. I do not mean an expensive latrine. There is the field form of latrines used in the army. It is simply a trench.

"*Witness*: But I think, you can hardly compare the Tamil coolie with the English 'Tommy'." (Ceylon, 1910, p. 6)

The very tenor of this exchange indicates the sharp divergence between the attitudes of the government officials and those of the plantation community. Fortunately, however, the 1910 medical committee recommended to the Colonial Office that good sanitary facilities were essential for the elimination of this disease. Thus, the authorities in Sri Lanka found the Colonial Office responsive to their attempt to enact legislation that would furnish the necessary powers to coax the planters into making such improvements. The Principal Civil Medical Officer said that: "With regard to recommendations, I have only one to make, viz. to legislate for the proper disposal of excreta" (Ceylon, 1910); and principally it was the power to prosecute and to enforce the maintenance of proper sanitary standards that was embodied in the new Medical Wants Act of 1912.

Ordinances Nos. 9 and 10 of 1912 gave the Principal Civil Medical Officer the power to prosecute a superintendent of an estate who did not comply with the regulations to be laid down by the Medical Department regarding coolie lines, latrines, bathing places and water supplies, while when disease had broken out he was empowered to condemn insanitary lines and carry out measures of improvement and reconstruction, the cost of which could be debited to the account of the estate. Again, on the threat of prosecution, every birth and death had to be reported within 48 hours to the district medical authorities, a measure which tended to improve the registration of vital statistics in the estate, especially since infringement was punishable by a fine of 500 rupees as compared with the 50 rupees earlier specified.

However, at the time of the First World War, the colonial Government did not want to disturb and incur the hostility of the planting community, because estate production was vital to the war effort. So a programme of systematic regulation of sanitary conditions in the estates did not begin until the 1920s under the impetus of an act passed in 1922 by the Government of India. Under this act, the methods of recruitment of labourers in India was controlled and the emigration of labourers was restricted to those countries which were prepared to take certain minimum measures for the safety and health of the immigrants. In Sri Lanka these proposals were embodied in the Ceylon Labour Ordinance No. 1 of 1923. The Department for Indian Immigrant Labour was created in 1923 to enforce these measures. Under the supervision of this Department a systematic attempt was made to enforce the provisions covered by the Medical Wants Act of 1912, and the period following 1923 saw a marked decline in mortality.

The enforcement of minimum standards meant the systematic collection of statistics. Hence, the demographic historian has detailed statistics, not only on mortality among the immigrants in the estate sector, but also on some of the factors that induced this great decline in mortality.

The crude death rate of immigrant labourers, which was 35.2 per 1,000 of the population in 1924, fell to 20.8 in 1931 (see table 25). Some of the factors at work in this change can be understood by examining the decline in the death rates from specific diseases.

TABLE 25. CRUDE DEATH RATE PER 1,000 POPULATION AMONG INDIAN IMMIGRANTS ON ESTATES UNDER THE MEDICAL WANTS ACT, 1924-1949

Year	*Crude death rate*	*Year*	*Crude death rate*
1924	35.2	1937	19.0
1925	31.2	1938	18.5
1926	30.0	1939	19.2
1927	28.2	1940	17.9
1928	27.6	1941	15.4
1929	25.1	1942	14.4
1930	22.1	1943	15.8
1931	20.8	1944	16.6
1932	18.7	1945	17.1
1933	18.9	1946	16.9
1934	21.1	1947	13.0
1935	26.7	1948	14.2
1936	19.4	1949	12.4

Source: Ceylon, annual reports of the Controller of Indian Immigrant Labour

The importance of ankylostomiasis, dysentery, diarrhoea and enteritis as causes of death decreased considerably during this period (see table 26). The death rate per million from dysentery, diarrhoea and enteritis together fell from 7,745 in 1924 to 2,264 in 1931, while the rate from ankylostomiasis fell from 2,223 in 1924 to 1,487 in 1931.

The fall in mortality must be attributed mainly to the efforts made after 1923 to provide better sanitary facilities and protected water supplies on the estates. Statistics with regard to the improvement in the estate sector are available only from 1927, by which date a substantial amount of this work had already been done. Even in 1927, 50 per cent of the estates visited by the inspecting medical officers had unprotected or partially protected supplies of water; this figure would have been even higher in 1924; however, it is significant that by 1929 this proportion had fallen to 22 per cent. Similarly, in 1927, 58 per cent of the estates inspected had either an insufficient number of latrines or no latrines, but by 1932 this proportion, too, had fallen to 20 per cent (see table 27). The great fall in the death rates from ankylostomiasis, dysentery, diarrhoea and enteritis occurred at a time of revolutionary change in the sanitary environment on the estates, and there seems to be no doubt that this change was the main reason for the decline in mortality during this period.

TABLE 26. DEATH RATE PER MILLION FROM SELECTED DISEASES AMONG INDIAN IMMIGRANTS ON ESTATES UNDER THE MEDICAL WANTS ACT, 1924-1941

Year	*Ankylostomiasis*	*Dysentery, diarrhoea and enteritis*
1924	2 223	7 745
1925	2 472	7 117
1926	2 233	6 111
1927	1 834	5 246
1928	1 811	4 628
1929	1 692	3 738
1930	1 601	2 846
1931	1 487	2 264
1932	1 322	1 668
1933	1 147	1 380
1934	1 284	1 717
1935	1 606	2 327
1936	1 081	1 411
1937	950	1 253
1938	1 034	1 192
1939	979	1 351
1940	794	1 100
1941	687	824

Source: Computed from data in the annual reports of the Controller of Indian Immigrant Labour.

TABLE 27. ESTATES INSPECTED UNDER THE MEDICAL WANTS ACT, 1927-1932

Year	*Number with sufficient latrines*	*Number with insufficient latrines*	*Number with no latrines*	*Percentage with insufficient or no latrines*
1927	234	198	129	58.3
1928	354	245	57	46.0
1929	461	225	24	34.1
1930	472	191	38	32.7
1931	477	182	32	31.0
1932	528	115	22	20.6
Year	*Number with protected water supplies*	*Number with partially protected water supplies*	*Number with unprotected water supplies*	*Percentage with partially protected or unprotected water supplies*
1927	199	85	116	50.3
1928	387	88	181	41.0
1929	258	16	57	22.1

Source: Ceylon, Administration reports of the Director of Medical and Sanitary Services.

NOTE: The figures for the years after 1931 include details regarding estate lines which were abandoned during the depression.

E. INFANT AND MATERNAL MORTALITY

One of the major aspects of the fall in mortality levels in Sri Lanka was the sharp decline in infant and maternal mortality. Although midwifery practice was an important element in early high levels and subsequent mortality declines, nutritional practices and sanitary conditions played important additional roles. The progress made in these areas and their effect on infant and maternal mortality can be documented in some detail for the city of Colombo and the estate sector. An analysis of events in these two areas may provide clues as to the factors responsible for the general pattern in Sri Lanka as a whole.

Infant mortality in Colombo

In the municipality of Colombo infant mortality was at a very high level at the beginning of this century owing to several causes of death (see table 28):

(*a*) A high death rate from neonatal tetanus was due to the infection of the naval of the infant by dirt during the separation of the umbilical cord. The Principal Civil Medical Officer of the Colony commented as early as 1879:

"The excessive mortality among children is due to bad midwifery and the absence of medical assistance at hand in case of difficulty, imperfect tying of the umbilical cord of the child so that it not infrequently bleeds to death, the habit of denying food to the women and child for three days after birth." (Ceylon, 1879, p.182)

(*b*) A high death rate from convulsions and digestive disorders was due to improper feeding and unsanitary environment. Traditional feeding practices often had ill effects. The Medical Officer of Colombo commented in 1911:

"There is widely prevalent custom amongst Sinhalese, Tamils, Moors and Malays whereby the newborn infant is given castor oil and sugar, or cow ghee and sugar, during the first three days, and he attributed many cases of digestive disturbance to this practice. He further points out that this custom has an injurious effect, inasmuch as the children are not put

TABLE 28. INFANT MORTALITY RATE PER 1,000 LIVE BIRTHS, BY MAIN CAUSES, COLOMBO, 1903-1939

Year	*Convulsions and developmental diseases*	*Pneumonia and bronchitis*	*Digestive diseases*	*Tetanus neonatorum*	*All causes*
1903	..	..	..	57	410
1904	..	..	..	53	353
1905	..	..	..	40	361
1906	..	..	..	..	300
1907	..	..	..	..	304
1908	198	54	55	29	355
1909	153	55	43	38	310
1910	149	46	48	31	295
1911	163	51	44	27	316
1912	164	52	38	18	299
1913	154	53	46	9	286
1914	151	37	39	5	260
1915	162	33	40	5	270
1916	150	28	30	3	234
1917	167	31	37	4	251
1918	158	51	32	5	266
1919	171	37	34	3	271
1920	151	32	31	2	233
1921	150	36	32	2	240
1922	148	36	33	2	247
1923	164	37	37	1	271
1924	149	31	34	3	239
1925	134	31	29	2	220
1926	127	28	28	2	204
1927	110	30	24	1	187
1928	108	27	20	1	181
1929	109	31	28	0.3	201
1930	105	24	26	1	180
1931	93	29	22	1.4	172
1932	90	29	22	0.6	171
1933	95	28	21	1.2	173
1934	100	30	23	0.8	189
1935	90	23	17	0.5	163
1936	73	29	22	0.3	150
1937	78	29	23	0.3	161
1938	76	24	20	0.2	151
1939	77	24	23	0.5	155

Source: Ceylon, Administration reports of the Municipal Council of Colombo.

NOTE: These rates are based on figures which also include some births and infant deaths among persons who were not permanent residents of Colombo city. Most deaths classified under convulsions and developmental diseases occurred during the first two months of life.

to the breast during these three days, the secretion of the milk being thereby much interfered with." (Ceylon, 1912)

Breast-feeding was also limited since many mothers were badly paid workers who had no time to breast-feed their infants regularly. Hence infants were weaned too early and fed on the cheapest type of condensed milk, a tin of which was made to last four days in tropical conditions in dirty crowded tenements. The same Medical Officer commented:

> "Can any person be surprised that the child gets convulsions, when such irritants as contaminated condensed milk mixed with we know not what kind of water are thrown into its stomach and bowels." (Ceylon, 1907, p.53)

The poor sanitary conditions described in the previous section were also responsible for the large number of deaths from digestive diseases.

(*c*) A high rate of mortality resulted from what were known as "developmental diseases", a group which not only included deaths due to congenital causes but also premature birth, atelectasis, atrophy, debility and wasting diseases. Many of these deaths were due to the lack of sufficient prenatal care of the mother, who was ill-nourished and living on starvation wages. These conditions were reflected in many of the new-born infants who succumbed very quickly in the first few days of life. The process was hastened by the fact that many of the mothers did not possess even the most elementary knowledge concerning the rearing of an infant.

The systematic beginnings of a programme to reduce infant mortality in Colombo was the result of a survey carried out in 1903 by the municipality, which showed the absence of trained midwives in the densely populated poorer quarters. In May 1905, the municipality appointed six midwives to work in the St. Paul's, New Bazaar, Kotehena, San Sebastian and Slave Island wards, which contained the main slum areas of the town. The effect of this step was clearly seen in the movement of the death rate from neonatal tetanus, which fell from an overall level in the city of 57 per 1,000 live births in 1903 to 9 per 1,000 in 1913, and afterwards declined still further until it was no longer a factor to be reckoned with as regards infant mortality in the city (see table 28).

However, the availability of trained midwives alone did not lead to a similar decline in the death rate from other causes. The tetanus death rate fell sharply because it needed only better techniques, a change in methods which could be supplied at very little cost to the city. Deaths from digestive diseases and respiratory infections showed only a slow decline, and the death rate from convulsions and developmental diseases remained unchanged. This was because the high mortality from these diseases was closely related to the low wages paid to the working classes, the resultant low levels of nourishment of the pregnant mothers and the effects of unhygienic feeding habits in an unsanitary environment. The Ministry of Health made these same points in 1923, indicating that high infant mortality was due to the wretched housing conditions of the poor, and poverty which compels the pregnant mother to work practically up to the last week of pregnancy and soon after birth of the child, and which drives her to feed her child on cheap unsuitable foods which alone she can afford to purchase. (Ceylon, 1924, p.75)

Owing to these circumstances, in 1925 the municipality established a separate department for maternal and child welfare. Clinics for mothers and children were held in the municipal dispensaries and two new dispensaries and two special child welfare centres were built in the period 1926-1931 in the slum areas of the city. These clinics were a significant innovation. Hitherto the only work in this direction had been that of the health visitors, although the number of visits made by these workers was large:

> "Advice without relief is to them like mustard without meat, and all the preaching and advice our staff gives is of little use, unless it can be accompanied by a certain amount of relief. The poor mothers by reason of their own physical condition cannot breast-feed their infants long enough to tide over the critical period." (Ceylon, 1924, p.66)

The health visitors faced a difficult situation for, not only had they to prevent the consumption of the cheap skimmed milk that was being dumped on the market, but they also had to offer an alternative to the poorer families who could not afford to buy anything better. The new department of child welfare attempted to solve some of these problems. The medical officer in charge of the department remarked:

> "Any infant appearing to be delicate and in need of milk, which the parents were unable to afford, are reported to me by the health visitors. I visit and examine such cases and, after making inquiries into the circumstances of the parents and satisfying myself, give order to specified dairies with whom I have made arrangements to them with free milk." (Ceylon, 1926, p.83)

This system was gradually extended in Colombo and in 1927 legislation was passed under which it was possible to stop the import of skimmed milk.

The department also held clinics at the various dispensaries and at the child welfare centres to attend to the medical needs of mothers and babies. The result was that infant deaths from convulsions and developmental diseases began to decline after 1924, as exhibited in table 28.

Maternal mortality in Colombo

From the early years of the century the provision of trained midwives in Colombo certainly led to a fall in maternal mortality, but since mortality statistics for the period do not clearly separate maternal deaths from others it is not possible to measure this decline. However, by the early 1930s maternal mortality had stablized around 20 per 1,000 live births (see table 29). More than half the maternal deaths were due to sepsis from infections contracted from unclean instruments used by the midwives. A census of midwives in the city in 1929 revealed that there were 46 unqualified midwives, and with the objective of both preventing them from practicing as well as supervising the work of trained midwives, it was made compulsory, under threat of prosecution, for all midwives in the city to be registered with the Department of Maternal and Child Welfare as from July 1930. Puerperal sepsis was also made a notifiable disease, by which it was hoped to identify those midwives who were care-

TABLE 29. TRAINED MEDICAL ATTENDANTS AND MATERNAL MORTALITY RATES IN COLOMBO, 1929-1942

Year	*No. of municipal midwives in Colombo*	*Percentage of resident births in Colombo delivered by municipal medical staff*	*Maternal death rate per 1,000 live births from all causes*	*Death rate from puerperal sepsis per 1,000 live births*
1929	12	18.1	21.0	10.6
1930	12	18.7	23.7	13.6
1931	18	22.4	18.5	8.3
1932	16	24.1	16.2	9.5
1933	. .	24.9	16.2	8.7
1934	19	28.8	20.7	12.5
1935	18	31.7	20.1	11.4
1936	22	34.4	12.7	6.9
1937	28	32.3	13.7	5.7
1938	28	34.1	12.3	6.1
1939	. .	35.1	12.1	4.3
1940	. .	. .	12.1	3.8
1941	. .	. .	11.1	. .
1942	. .	. .	8.4	. .

Source: Ceylon, Administration reports of the Municipal Council of Colombo.

less and lacking in technical skill; surprise visits were then paid to these midwives. The medical officer in charge of the department "paid surprise visits to these midwives to examine their bags and instruments and in a good many cases found them in a filthy state. All midwives guilty of such negligence were forced by threat of prosecution either to get a completely new set or to renovate the unsatisfactory parts". (Ceylon, 1933, p.125)

This particular method of taking action against unqualified midwives without providing alternative services was partially successful, as can be seen from table 29. The maternal death rate declined to 16 by 1933 and would have continued to fall in the following years if it was not for the catastrophic malaria epidemic of 1934-1935. The decline up to 1933 might have been more steep, but even as late as 1937 a survey of private midwives in the city indicated that: "a good percentage had not the necessary equipment for midwifery practice. Not a single midwife had kept a register. Some were very old and infirm and physically unfit for work. One was totally blind." (Ceylon, 1938, p.160)

Whatever the law, in the absence of a qualified midwife, the pregnant mother was forced by circumstances to seek the aid of others. A breakthrough occurred only when the municipality provided a more comprehensive service for the welfare of expectant mothers. Mortality rates declined only with the increase in the number of municipal midwives (see table 29) and with the opening of three maternity homes by the municipality in 1935-1936. Since the maternity homes did not charge fees, they were very popular and were "a great boon to the poor mothers. They consider the home as a safe refuge and feel a sense of security in entering it. Here the mothers are delivered under aseptic conditions and for 10 days they have the necessary care and attention which they can never expect in their homes." (Ceylon, 1937, p.163)

The death rate fell sharply in 1936, the year in which the three homes came into operation, and there is little doubt that these infection-free maternity homes were one of the main factors responsible for the reduction of the death rate from puerperal sepsis among mothers from the slums.

In sum, it was both the increase in the number of trained midwives and the provision of free maternity homes that made possible the considerable reduction in maternal mortality in Colombo in the period 1930-1940.

Infant and maternal mortality on the estates

The relationship between high infant and maternal mortality levels and unhealthy midwifery practices and the decline in infant mortality levels with the introduction of trained midwives can also be documented for the estate population. Maternal and infant mortality in the estates declined sharply in the period 1935-1942—infant mortality from 198 to 120 per 1,000 live births and maternal mortality from around 20 to 9. Infant and maternal mortality in the estates was very high in the early 1930s largely due to the prevalence of traditional practices of antenatal and post-natal care, together with unhygienic and primitive methods of delivery. Traditional practices did not allow proper nourishment of mother or child until the third day after birth, while the infant was at the very least exposed to grave risk of infection because it was fed various decoctions. The position was very aptly described in 1929 by one of the inspecting medical officers:

> "The treatment given to pregnant mothers by line Dhais is too harrowing to be described in detail. As regards the food given to mother and child, he states that soon after the birth of an infant a decoction sufficient for 10 days is made of 27 ingredients consisting of herbs, seeds, grain and roots, and for 3 days after the birth of the child the mother is given no nourishment beyond 4 cups of the nauseous decoction sweetened with "jaggery" and an occasional cup of coffee or thin rice cunji. Thereafter, the decoction is continued up to the tenth day with increasing quantities of food of little nutritious value.
>
> "The infant is given a little powdered nutmeg obtained by grating it against the curry stone 'to cut the phlegm' and with it disease-bearing germs are introduced into the infant's stomach, frequent doses of castor oil and sugar are further administered to irritate the intestinal tract of the infant who is kept away from the breast for 3 days. It is unnecessary to describe here the various unhygienic things done . . . and it is no surprise to find a large number of the infants die of debility, and that mothers so enfeebled fall easy victims to septic infections." (Ceylon, 1930, p.27)

These methods were used because there were no trained midwives to replace the line *dhais*, the traditional midwives who attend the expectant mothers and whose advice was followed with regard to the rearing of infants. Conditions were so bad that Dr. Ludovic, one of the inspecting medical officers, considered that "33 per cent of the infantile deaths could be prevented if qualified midwives were employed and obeyed". (Ceylon, 1927, p.17)

The attitude of the estate population to innovation in these matters was also not encouraging, and it is recorded that a planter's wife (a qualified doctor) who attempted to do antenatal work, was forced to give up as a result of the opposition of the labour force. The persistence of tradition was to some extent reinforced by the fact that the immigrant population was mainly drawn from the depressed castes in South India who, because of their lack of education and their isolated position in society were not able immediately to appreciate the advantages of modern methods of health care. The reports of the medical officers of the period contain many references to the "stubborn conservatism of the estate labourers", (Ceylon, 1931, p.22), and of their failure to make use of the maternity rooms and other facilities available on the estates. There is no doubt that some of these comments were justified, but what is questionable is whether this reluctance to adopt new methods was so deeply ingrained. As in an earlier period when doubts were cast on their ability to use latrines, one has the uncomfortable feeling that these mothers were never instructed in the use of the available facilities. The estate mother was quick to adopt more healthy measures when there was someone to instruct and explain them to her. When trained midwives were provided on the estates, the estate mother was quick to use their services. In the period 1936-1942, when the number of trained midwives on the estates more than doubled, both the infant and the maternal mortality rate took a sharp plunge (see table 30).

TABLE 30. INFANT AND MATERNAL MORTALITY PER 1,000 LIVE BIRTHS OF THE INDIAN POPULATION IN THE ESTATES UNDER THE MEDICAL WANTS ACT, 1924-1949

Year	*Infant death rate*	*Maternal death rate from all causes*	*Maternal death rate from puerperal sepsis*	*No. of trained midwives*
1924	247	18.0	7.2	. .
1925	216	17.0	8.3	. .
1926	209	16.3	8.0	. .
1927	228	20.0	9.1	. .
1928	211	19.5	9.0	. .
1929	213	20.6	9.8	. .
1930	194	22.9	10.3	93
1931	184	20.4	9.1	109
1932	188	17.2	7.6	89
1933	181	16.9	8.4	86
1934	200	17.9	8.7	82
1935	198	21.2	8.7	96
1936	172	17.0	8.3	121
1937	169	18.2	8.0	160
1938	171	16.2	7.4	170
1939	169	15.0	6.5	191
1940	149	13.7	5.6	241
1941	119	12.6	4.8	275
1942	120	8.7	3.0	283
1943	122	9.0	2.8	266
1944	129	8.8	3.0	239
1945	126	10.2	3.7	282
1946	134	10.8	2.9	275
1947	109	6.4	. .	276
1948	112	6.8	1.6	277
1949	111	5.1	1.5	272

Source: Ceylon, Annual reports of the Controller of Indian Immigrant Labour.

In conclusion, there were thus three elements contributing to the decline in infant and maternal mortality in Sri Lanka. First the gradual displacement of untrained midwives whose unhygienic methods of delivery were a danger to both mother and child by a trained cadre of midwives whose services were provided free to the public. The second part of the strategy was the establishment of maternity and child welfare centres where pregnant mothers and infants were examined, child care advice given and in some instances free milk given to the needy. The third crucial element in the attempt to bring down maternal and infant mortality was by opening maternity homes where deliveries could be conducted in conditions that were comparatively free of infections. However, in the first four decades of this century all these were not carried out together as one policy package but in stages, one followed by the other, for essentially the policy-makers in charge of the delivery of health services had to learn by test and experience the intervention measures that could lower mortality. No assessment of the decline in infant and maternal mortality during the years after the Second World War can neglect the contribution made by these services in the light of their massive expansion during these years.

F. MALARIA ERADICATION AND ITS EFFECTS ON MORTALITY

The presence of endemic and epidemic malaria was one of the main reasons for the prevalence of high mortality in Sri Lanka (Harrison, 1978). Malaria had a two-fold effect on mortality levels. By itself it caused a significant number of deaths. In addition, and perhaps more seriously, it acted to lower the general health and resistance to disease of the population and hence increased susceptibility to other diseases, particularly respiratory and diarrhoeal infections. In order to understand the effect of malaria eradication in the period 1947-1952 on mortality levels it is necessary to describe the distribution of malaria by regions in the country.

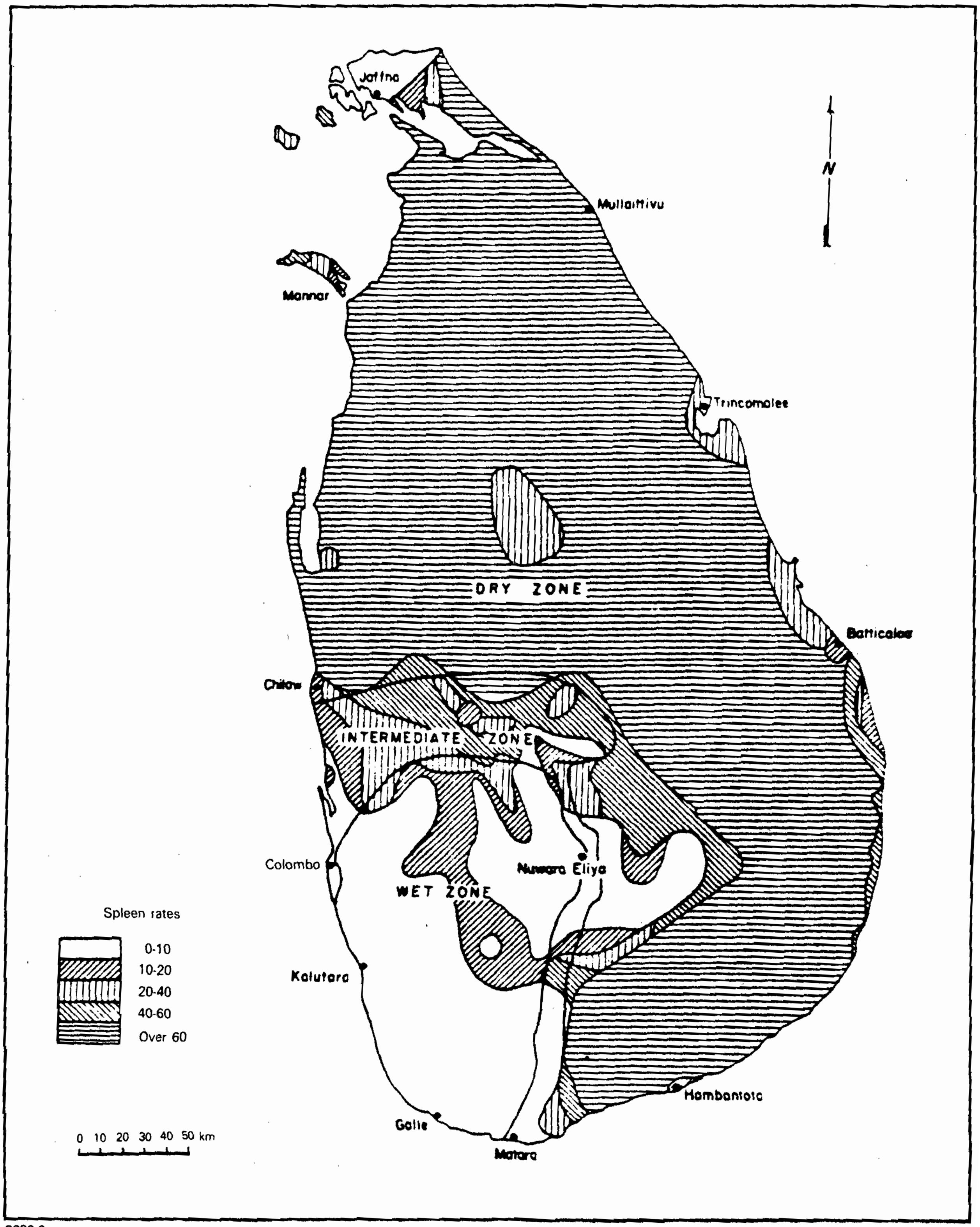
The ecology of malaria

Malaria in Sri Lanka depended on the extent to which conditions favoured the breeding of the vector mosquito anopheles culiciefacies. The areal prevalence of the mosquito was related to differences in physical and climatic features within the country. Sri Lanka can be broadly classified into three rainfall zones: the wet, intermediate and the dry, as seen in map 2, with annual average rainfall ranging from 100 to 200 inches in the wet zone to 0 to 75 inches in the dry zone. Malarial intensity as measured by spleen rates (map 2) is closely related to the distribution of rainfall.*

In the dry zone the stagnant water collected in the profusion of irrigation channels and tanks constructed in ancient times for irrigation purposes served as a convenient breeding place for the larvae of the vector mosquito. Although malaria was endemic and prevalent throughout the year, there was a seasonal rise in malaria during October to March, the period of the north-east monsoon, which led to the filling of the tanks. It was only the failure of the monsoon, and the drying up of these tanks,

* There are two important exceptions to be made to this climatic-malarial classification of the country. Although the Jaffna peninsula in the north belongs to the dry zone, a large part of it, as is seen in map 2, did not have endemic malaria. The central highlands of Sri Lanka, mainly those falling within the Nuwara Eliya district, belong to all three rainfall zones but are not affected by endemic malaria since the steep descent of the fast-flowing rivulets of the hill country are not conducive to the breeding of the vector mosquito.

Map 2. Distribution of malaria in Ceylon: spleen survey, 1938



3333.2x

Source: K. J. Rustomjee, "Observation upon the epidemiology of Malaria in Ceylon", Sessional Paper 24 of 1944 (Colombo, 1944), map IV.

that led to a decrease in the breeding of mosquitoes and to a reduction in malarial intensity.

In contrast, agriculture in the wet zone was not tank-irrigated since it had the benefit of two monsoons together with an abundance of water from several rivers. The amount of stagnant water and the scope for mosquito-breeding were thus limited.

In normal times, when the monsoons do not fail, the flowing water ensures that mosquito-breeding and malaria are at a minimum. But when the monsoons do fail there is disaster, for stagnant water then collects in sand and rock pools in the river beds, leading to the rapid multiplication of mosquitoes and to the outbreak of epidemics. Unlike in the dry zone, where endemic malaria leads to the creation of a natural resistance in the population (Macgraith, 1948), the outbreak of an epidemic of malaria among a population that has not been continually exposed to it and that thus does not have this naturally induced resistance leads to very high mortality rates. Malaria generally has devastating effects on populations that are affected by it for the first time or that are exposed to it only intermittently. John Davy, a medical officer attached to the British army in Ceylon, writing in 1821, commented that of 250 European soldiers stationed in the interior of the Eastern Province during the War of 1818 only 3 survived the raging endemic fever. The famous Ceylon malaria epidemic (Ceylon, 1935) of 1934-1935 occurred following a drought in the non-endemic zone. The drought led not only to an epidemic but also to a famine consequent upon the failure of the crops. Infant mortality levels in the Kegalle district, which belongs to both the intermediate and non-endemic zone, showed a phenomenal rise to over 500 per 1,000 from levels between 115-140 during the years before and after. (Ceylon, 1930-1943)

However, the intensity of malaria was only one of the determinants of the level of health and of mortality in an area. The other important factors were the availability of medical services, the standards of public health, and the levels of nutrition, all of which were in turn a function of the social and economic development of an area.

Prior to 1945 the distribution of these other factors was broadly similar to that of malaria. The south-west zone and the central hills which had abundant supplies of water formed a relatively prosperous region where, together with a small holding peasantry cultivating rice and various cash crops, there was a plantation sector based on coconut, rubber and tea. The surplus generated from export proceeds made it possible not only to import a stable supply of food but also to finance the construction of a network of local hospitals, primarily for the benefit of estate labourers which gradually came to be used extensively by the peasantry.

The money economy generated by the cultivation of cash crops also led to a modernization process in the rural sector. Cash crops and wage labour led to a rise in nutritional levels based on the purchase of cheap imported food. The raising of educational levels was accompanied by a rise in public health standards, the use of hospital services, the spread of midwifery services, maternity and child welfare centres and other measures designed to improve the standard of living of the villager. This zone was therefore not only free from endemic malaria, but it was also relatively well endowed with health services.

By contrast, agriculture in the dry zone depended on irrigation fed from reservoirs. For centuries many of them had been destroyed or were in a state of disrepair, and agriculture was of a very primitive type characterized by slash-and-burn methods of cultivation (Pelzer, 1948). Malnutrition was inherent in this type of cultivation and at most a few types of cereals such as kurrakkan and Indian corn dominated the diet. Further, since the productivity of this type of agriculture was extremely low, no surplus was left as insurance for a bad year. But what was still more damaging to the health of the population was that this type of subsistence agriculture rarely yielded sufficient produce to last the year round. (Stamp, 1960, p.58)

In this type of nutritional environment, the population was particularly prone to malarial fevers, and respiratory and diarrhoeal infections. The effect of starvation and malaria on infant mortality was described by a doctor stationed in Anuradhapura in the heart of the dry zone:

> "The chief cause of infant mortality in the town appears to be marasmus caused by improper feeding. A large number of the mothers are debilitated by malaria and hookworm and are unable to nurse their babies and so they resort to various cheap artificial methods of feeding viz. corriander water and tea. Owing to this poverty of the villagers in this district they are unable to afford other more satisfactory artificial foods for their infants. Such infants become marasmic and die sooner or later." (Ceylon, 1933, p.15)

To add to the difficulties, health facilities were minimal in these areas. In addition, the hospitals in the dry zone were much more poorly equipped and staffed than those in the rest of the country. Out of 100 hospitals in Ceylon in 1938, 79 had maternity wards and the majority of those without wards were in the malarial zone. Even more significant, hospitals in the malarial zone were sited only in urban centres and were of limited use to a population thinly spread over a very wide area (see map 1), poorly served with roads and transport services. In the non-endemic zone the much better transport facilities essential for the running of the plantation sector were available to a population which lived in much more concentrated groups.

The gap was further increased by the existing imbalance in the other paramedical services, such as skilled physicians or trained midwives. Midwifery services were generally expected to be provided by local authorities, which in the rural sector were the village committees. In the dry zone these committees were too poor to provide such services.

In the dry zone no attempt was even made to do maternal and child welfare work among the rural people until the late 1930s. When attempts were made to provide these services in the years after 1937, the shortage of trained personnel proved an almost insuperable obstacle. The consequences for mortality levels of these several differences between regions is seen in table 31.

Thus it was not malaria alone but also a generally unhealthy environment, lack of elementary maternal and child welfare services, malnutrition (and at times starvation) as well as the lack of medical services which were

Table 31. Infant mortality rate per 1,000 live births, 1936-1948

Year	Non-endemic zone	Endemic zone	Intermediate zone
1936	140	247	144
1937	143	221	136
1938	141	233	143
1939	140	228	160
1940	131	212	133
1941	115	184	114
1942	106	169	107
1943	111	199	117
1944	120	196	117
1945	117	208	127
1946	108	248	130
1947	95	128	90
1948	92	103	84

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics for the years 1936 to 1948.

Table 32. Malaria cases by species, Sri Lanka, 1963-1980

Year	Total no. of cases	P. vivax	P. falciparum
1963	17	9	5
1964	150	12	69
1965	308	19	200
1966	499	25	161
1967	3 466	3 194	202
1968	440 644	439 678	951
1969	537 705	554 214	2 995
1970	468 202	466 587	1 358
1971	145 368	141 442	3 721
1972	132 604	129 135	3 245
1973	227 715	218 139	9 378
1974	315 448	209 241	25 180
1975	400 777	336 924	63 853
1976	304 037	285 695	18 792
1977	262 467	251 726	10 734
1978	69 685	67 809	1 876
1979	48 004	46 636	1 368
1980	47 949	46 474	1 475

Source: A. M. Abeysundere, "Recent trends in malaria morbidity and mortality in Sri Lanka", in *Population problems of Sri Lanka* (Colombo, 1976), and unpublished data with the Superintendent, Anti Malaria Campaign.

responsible for the different mortality levels between these regions.

The malaria control programmes

It was in this context that the Ceylon Government initiated and carried out its malaria eradication programme. DDT spraying, which began in 1945, fully covered the endemic zone by the middle of 1946 and the entire island by 1947. The recorded malarial mortality rate fell by a factor of five from over 1,000 deaths per million persons before 1947 to around 250 by 1950 (Gray, 1974). However, how much of the overall mortality decline from a crude death rate over 20 in 1945-1946 to 12 in 1949 was due to the spraying is a matter of some controversy. The differing estimates vary from 20 to 50 per cent, depending on the statistical model used (Newman, 1965; Newman, 1970; Meegama, 1967; Gray, 1974; Newman, 1977). The key problematical question is, as indicated earlier, how the spraying programme interrelated with the host of other health-related changes that were occurring during the same period, particularly in the hitherto neglected dry zone (Meegama, 1969).

Revival of malaria

By 1963 the number of cases of malaria had reduced to 17 and the general routine spraying with insecticides was stopped in 1964. However, since 1967 there has been a large-scale revival of malaria in some districts (see table 32) and it has once again become a major health problem in Sri Lanka. Although the time period considered here is much more recent than that covered in this study the very differing effects of malaria on mortality are of sufficient importance to be included.

It is possible to attempt an evaluation of the effects of the resurgence of malaria on mortality levels by comparing the level of mortality before and after the revival between districts severely affected by the disease and districts that were not malarial. Figures of annual parasitic incidence of malaria by district are available (see table 33) and it is possible to compare the trend in the death rate where malaria was hyperendemic with those districts that were not malarial.

In nine districts the malaria epidemic lasted at a high level of intensity for the years 1968 to 1970, and although it declined in 1971, malaria seemed to have become endemic in these districts. The crude death rate for these districts for the three years of the epidemic was compared with the crude death rate for three years before the epidemic and the three years after the epidemic (see table 34).

In six of the nine malarial districts the crude death rate increased by amounts ranging from 1 to 20 per cent, in two it remained stable and in one it declined during the malarial years 1968 to 1970 in comparison with the average for the three previous years before the epidemic. In eight districts after the decline of the epidemic the death rate decreased, also the average for the years 1970 to 1973 was less than that for the non-malarial period 1965-1967 in seven of the districts, indicating that the decline in the death rate due to the influence of various factors had been temporarily disturbed during the height of the malarial epidemic. It is highly possible that the factors inducing the decline in the death rate after the epidemic were operative even during the malarial years, so that there were two contrary factors acting on mortality levels during the years 1968 to 1970, and that the increase in the death rate due to malaria as reflected in the rise in the crude death rate underestimates to some extent the impact of malaria on mortality levels. However, the presence of certain other factors also makes the evaluation of the effect of malaria on mortality levels more difficult. A World Health Organization team which surveyed the effects of the epidemic concluded that it is difficult to say whether the increase in mortality was due to malaria or to "an outbreak of influenza (which occurred in some districts between January and June 1969) or to other factors, such as drought in North-East of Ceylon in 1968." (Visvalingam, Black and Bruce-Chwatt, 1972)

It is possible, however, to attempt to disentangle the effects of some of these factors. A comparison with non-

TABLE 33. ANNUAL PARASITE INCIDENCE IN SRI LANKA SHOWN BY DISTRICT, 1965-1971

	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971
Jaffna	0.001	0.001	17.86	17.85	28.88	7.36
Vavuniya	0.001	0.001	109.46	174.08	294.05	58.84
Lannar	0.001	0.001	114.54	97.91	131.75	20.66
Anuradhapura	0.19	0.34	153.15	257.65	383.33	95.32
Trincomalee	0.40	0.001	62.92	150.02	229.35	53.15
Puttalam	0.16	0.04	50.76	64.12	141.74	30.13
Kurunegala	0.06	0.38	71.51	57.99	100.90	40.27
Matale	0.001	0.83	131.86	106.89	133.32	33.83
Polonnaruwa	0.28	1.06	52.44	155.13	194.31	68.81
Batticaloa	0.29	0.03	17.24	99.11	78.52	20.21
Ampaari	0.08	0.14	6.63	70.28	31.41	13.94
Moneragala	0.01	1.00	69.41	251.46	284.16	96.38
Badulla	0.01	0.01	9.86	18.73	10.63	3.47
Hambantota	0.04	0.03	99.49	100.04	84.26	70.24
Matara	0.001	0.001	2.53	7.43	7.98	5.39
Galle	0.01	0.001	0.52	0.78	6.51	0.14
Ratnapura	0.03	0.05	26.23	47.60	28.54	29.02
Kagalle	0.001	0.01	2.90	5.28	8.71	1.88
Kandy	0.001	0.12	6.53	6.04	6.61	1.98
Nuwara Eliya	0.001	0.001	0.001	1.32	1.92	9.77
Colombo	0.01	0.02	0.61	0.92	2.01	0.43
Kalutara	0.001	0.001	0.10	0.73	0.10	0.10

Source: T. Visvalingam, Robert H. Black and L. J. Bruce-Chwatt, *Report on the Assessment of the Malaria Eradication Programme in Ceylon* (New Delhi, World Health Organization Regional Office, 1972).

TABLE 34. COMPARISON OF MORTALITY LEVELS BEFORE, DURING AND AFTER THE MALARIA EPIDEMIC, SRI LANKA

District	Crude death rate			Infant mortality rate		
	1965-1967	1968-1970	1971-1973	1965-1967	1968-1970	1971-1973
Malarial						
Anuradhapura	6.4	6.7	6.0	38	43	38
Polonnaruwa	5.2	5.2	4.5	41	34	27
Trincomalee	5.7	6.7	6.2	41	41	30
Vavuniya	6.8	6.8	5.0	39	45	35
Matale	8.6	8.0	8.5	55	51	53
Moneragala	7.2	7.4	5.4	47	45	35
Mannar	7.9	8.8	7.5	53	54	40
Puttalam	7.4	7.8	7.4	39	45	36
Hambantota	6.0	6.1	5.0	41	40	35
Non-malarial						
Colombo	8.3	8.1	8.3	48	42	42
Galle	7.0	7.5	7.5	48	51	44
Kalutara	7.7	7.5	7.1	51	52	56

Source: Sri Lanka, Department of Census and Statistics, *Bulletin on Vital Statistics, 1977.*

malarial districts indicates that the crude death rate declined in the latter area even in the epidemic years 1968 to 1970. This would seem to strengthen the basis for thinking that malaria was a decisive factor which led to an increase in mortality in the areas where there was an epidemic. But it is possible that the non-malarial districts where mortality declined did not suffer from influenza and drought.

However, too much should not be read into these figures; the increases and decreases are too small to be attributed with any certainty to specific causes.

But whether there was a small increase or not in mortality because of malaria, it is striking that the impact of the malaria epidemic on mortality was so small, unlike in the pre-war period, when mortality rose sharply during epidemic years. Also the 1968-1970 epidemic struck a population which had not been exposed to malaria for some time and which therefore did not have immunity. This was so especially with children born during the non-malarial years just prior to the epidemic who had never been exposed to any malaria. According to past patterns, the effect of the epidemic should have been much more severe. But in four of the nine malarial districts, infant mortality actually declined during the epidemic years.

It is possible that anti-malarial drugs had to some extent mitigated the effects of the epidemic, while it must also be considered that the epidemic was predominantly due to vivax malaria and not to the more deadly malaria falciparum. However, even in the earlier period when mortality was high, cases of falciparum malaria were consistently low (Carter, 1927). A preliminary survey of the data indicates that even a district where falciparum cases had increased did not have a significant increase in mortality. Moneragala is the only district where falciparum is a long-standing problem. But the district death rate is one of the lowest for the country (see table 34). What may very well be illustrated here is the reduced fatality from malaria under conditions of stable nutritional levels, sufficient medical and public health services and healthier populations.

G. Additional observations

The mortality decline in Sri Lanka took place in various phases, each with its own etiology. Greater availability of food, a reduction in the number of famines and the control of cholera epidemics led to a decline in mortality during the first phase in the second half of the nineteenth century.

The decline in the second phase started well before the Second World War and before the advent of antibiotics and malaria eradication. It occurred among both sexes and all age groups in both the endemic and the non-endemic malarial zones. One of the main factors leading to the decline was the expansion of maternity and child welfare services wich lowered infant mortality as well as mortality among women in the reproductive age groups. There were other factors which may have led to a decline of mortality. These were:

(a) *The expansion of curative services.* However, in the absence of antibiotics the significance of the impact of hospital treatment on mortality is open to question other than the provision of food and hygienic care especially to the poorer groups of the population;

(b) *Improvement in the quality of drinking water and sanitation.* In the urban areas and the plantations, as was described, these were significant factors leading to the decline in mortality from diarrhoeal diseases. It is also possible that among the more affluent classes in other parts of the country improvement in the quality of water and sanitation were significant factors leading to a decline in mortality;

(c) *A greater availability of food.* The decline of mortality levels in the dry zone before malaria eradication would seem to indicate that greater availability of food was a factor which continued throughout the twentieth century to influence the decline in mortality levels, in particular from diarrhoeal diseases;

(d) *Better nutrition, improvements in sanitation and the provision of uncontaminated water.* These led to a decline in diarrhoeal diseases. It is also possible that the consequent improvement in health led to higher resistance to respiratory infections, mainly pneumonia and bronchitis.

In addition to the above factors, rising standards of living certainly played important roles in the mortality decline during the second phase. A rising standard of living, as reflected in better housing, an improvement in personal hygiene and improved transport facilities led to gradual changes in mortality over the decades. These effects are difficult to trace to any particular cause. And sometimes in a poor environment the effect of such improvements is totally concealed and is not even reflected in the death rate because of the operation of conflicting factors.

One factor underlying improvements in living standards was the gradual rise in educational levels of the population (see table 35). The educational attainments of the population are an indicator of its rising aspirations and consciousness. At the turn of the century there was a great gap in literacy levels between men and women; however, the Dononghmore reforms of 1931 granting universal adult franchise led to heavy investments in education and to a rise in literacy, and narrowed the gap between men and women. The resulting rise in aspirations had the effect of improving health awareness and thereby of increasing investments in health at the household and public level.

Table 35. Percentage of literate population aged 10 and over, Sri Lanka, 1881-1971

Census year	*Males*	*Females*
1881	29.8	3.1
1891	36.1	5.3
1901	42.0	8.5
1911	47.2	12.5
1921	56.4	21.2
1946	70.1	43.8
1953	75.9	53.6
1963	79.3	63.2
1971	85.6	70.7

Source: Committee for International Co-operation in National Research in Demography, *The Population of Sri Lanka* (Colombo, 1974).

As discussed earlier there were great differentials in mortality levels between districts in the earlier decades of this century, indicating the presence of sharp differentials in the factors that determined health status. Did mortality differences bear any relation to the differentials in literacy levels between districts? Literacy levels based on the 1921 and 1946 censuses can be related to mortality levels during this period (see table 36). The comparison was restricted to the districts that did not

Table 36. Female literacy aged 5+ and mortality of female children aged 1-4, and female mortality aged 25-34, for the Sinhalese population of districts without endemic malaria, 1920-1922 and 1944-1946

(Percentage)

Period		*Galle*	*Nuwara Eliya*	*Chilaw*	*Megalle*	*Kalutara*	*Ratnapura*
1920-1922	Literacy	27	10	46	10	34	9
	Child mortality	53	53	27	42	42	47
	Female mortality	12.8	13.5	17.6	12.5	11.2	13.2
1944-1946	Literacy	50	37	67	41	61	34
	Child mortality	40	48	31	33	29	38
	Female mortality	8.5	7.0	10.8	8.6	7.3	9.6

Source: Computed from data in the reports of the Registrar General of Ceylon on vital statistics and from the censuses of Ceylon.

have endemic malaria in order to keep the malaria factor out of the comparison. Female rather than male literacy seemed a better indicator of modernization, especially in relation to matters affecting nutrition, health and the care of children. Also male literacy levels did not differ very much between districts and might thus not be as good an indicator of differences in the level of living between districts.

In the earlier years, as the data for 1921 indicate, mortality was high and there were significant differences in literacy levels between districts. However, there was no clear correlation between literacy and either child or female adult mortality. By 1946, when literacy levels increased significantly in all districts, there seemed to be a strong inverse relationship between literacy and child mortality. (Although, in Chilaw while female literacy increased from 46 to 67 per cent between 1921 and 1946 child mortality increased.)

Female mortality in the reproductive age groups, however, seems to have decreased together with the increase in literacy in all districts between 1921 and 1946, but the correlation between the level of female mortality and female literacy in a district was weak both for 1921 and 1946. One of the reasons for the weak correlation could be the influence of other variables such as economic and nutritional levels which tended to vary sharply between districts.

It is possible that a study of data on mortality, literacy and associated variables at the level of the household could yield a better understanding of the interrelationships between these variables, but unfortunately no such data are available for the pre-war period.

The mortality decline in the third phase in the years after the Second World War also raises various issues. In the endemic zone malaria eradication was a major factor which led to the decline in mortality and it could even be argued that if malaria had continued to prevail in this neglected region the impact of improved health services would not have been significant, since it would have been difficult to attract and keep for long periods personnel such as midwives, dispensers and other paramedical personnel.

However, over 70 per cent of the population lived in areas which did not have endemic malaria and the decline in mortality in these areas during this period should be viewed as due to a combination of factors, the principal ones among them being the introduction of a subsidized food distribution system accessible to all sections of the population and the use of antibiotics provided through a network of hospitals which were established throughout the country in this period.

The chain of events leading to this heavy investment in social welfare was set into being by the constitutional reforms of 1931 under which self-government in domestic affairs was granted to the colony. Power was transferred to a Council of Ministers elected from a legislature, and what was even more important, for the first time in Sri Lanka members of the legislature were elected by universal adult franchise. Thus in domestic affairs the power of policy-making was transferred from the colonial bureaucracy to men who were held to account by the mass of the people, and the welfare of the neglected came to exert a dominant influence in the framing of policy. Gunnar Myrdal commented that the British Labour Government of 1931 granted universal adult suffrage in the face of opposition from the Ceylonese upper classes, because the British Labour Government "wanted to strengthen the hand of the lower classes in their dealings with the ruling class . . . ." (Myrdal, 1968, p. 157). Myrdal also remarked that:

> "Women in Ceylon were enfranchised on the same basis as men in 1931, well before the women of any other Asian country. The reason given was that women's services would be of special value in coping with the high infant mortality rate in the island and with the need for better housing and improved child care, midwifery, and prenatal services."

With universal adult suffrage the pressure of the planting interests and the richer classes to limit the size of the public purse was no longer so effective. This change in the power structure was almost immediately reflected in a measure passed by the legislature, whereby for the first time in Sri Lanka a direct tax was levied on incomes, commencing from the year 1932. Thus new sources of income were made available for investment in various welfare schemes.

Differentials by sex and population group also have been of significant importance throughout all phases. Trends in sex differentials in mortality have differed over the years for both males and females (see table 37). Among children the gap in male and female mortality narrowed sharply in absolute terms over the years; however the mortality of female children continued to remain about 20 per cent higher than that of males over the period 1920 to 1971, indicating the continued presence of discrimination in favour of sons either in medical treatment in times of illness or in the intrafamily distribution of food.

Table 37. Sex differentials in mortality among children aged 1-4, Sri Lanka, 1920-1971

Year	*Mortality rates* Male	*Mortality rates* Female	*Sex differentials in mortality* Absolute difference	*Sex differentials in mortality* Female as percentage of male
1920-1922	46.7	55.0	8.3	117.8
1945-1947	24.9	30.0	5.1	120.5
1952-1954	17.1	20.5	3.4	119.9
1962-1964	8.3	9.8	1.5	118.0
1971	5.1	6.0	.9	117.7

Source: Computed from T. Nadarajah, "Trends and differentials in mortality" in Economic and Social Commission for Asia and the Pacific Monograph, *Population of Sri Lanka* (Bangkok, 1976).

The sex differentials in mortality among adults in the reproductive age groups, however, has changed in favour of females. To take an example, during the first half of this century mortality among women aged 30-34 was very much higher than for men in the corresponding age group (see table 38). However, by 1971 not only had adult mortality decreased greatly, but also female mortality was lower than that of males.

Although mortality levels in Sri Lanka had declined by the 1970s to levels that were very low by most third world standards, it must be noted that they were yet significantly higher than those prevailing in Cuba (see table 39), which also faced the same problems as Sri Lanka with an economy heavily dependent on the export of primary products. One reason for the presence of this differential was the persistence of pockets of high mortality among certain groups of the population (Meegama, 1982). Mortality in the estates, for example, is significantly higher among the young, the aged and the women than among the rest of the population (see table 40). The persistence of sharp class differentials in the mortality among children was indicated in estimates based on the data collected in the World Fertility Survey in 1975 (see table 41).

Neonatal, post-neonatal and child mortality among certain classes and groups in the population was much higher than among the rest. Mortality was found to be especially high among the estate population, and among the families of the landless labourers in rural Sri Lanka and the casual labourers in the towns and cities. Estimates indicate that they comprised approximately 25 per cent of the population of the country. The next phase of the mortality decline in Sri Lanka can begin only when programmes are formulated to solve the problems of this submerged quarter of the population.

TABLE 38. SEX DIFFERENTIALS IN MORTALITY AMONG ADULTS AGED 30-34, SRI LANKA

Year	*Mortality rates*		*Sex differentials in mortality*	
	Male	*Female*	*Absolute difference*	*Female as percentage of male*
1920-1922	12.9	19.3	6.4	149.6
1945-1947	7.8	11.7	3.9	150.0
1952-1954	2.9	4.9	2.0	169.0
1962-1964	2.4	3.3	.9	137.5
1971	2.8	2.5	−.3	89.3

Source: Computed from T. Nadarajah, "Trends and differentials in mortality" in Economic and Social Commission for Asia and the Pacific Monograph, *Population of Sri Lanka* (Bangkok, 1976).

TABLE 39. AGE-SPECIFIC DEATH RATES BY SEX, SRI LANKA, 1971 AND CUBA, 1965

Age	*Males*		*Females*	
	Sri Lanka 1971	*Cuba 1965*	*Sri Lanka 1971*	*Cuba 1965*
Under 1	54.0	10.6	44.9	9.0
1-4	5.1		6.0	
5-9	1.5	.5	1.7	.4
10-14	1.1	.6	1.0	.5
15-19	1.5	1.2	1.4	1.0
20-24	2.2	1.7	1.8	1.2
25-29	2.6	1.6	2.4	1.2
30-34	2.8	1.6	2.5	1.5
35-39	4.1	2.3	3.2	2.0
40-44	5.4	3.1	3.4	2.6
45-49	7.6	4.4	4.7	3.9
50-54	10.4	7.5	6.3	5.9
55-59	15.3	11.6	9.9	8.7
60-64	21.3	21.5	15.3	14.0
65-69	32.6	29.7	26.3	17.8
70-74	52.6	52.0	47.1	31.6
75-79	85.4	. .	68.0	. .
80-84	131.0	. .	126.3	. .

Source: Demographic Yearbook 1974 and T. Nadarajah, "Trends and differentials in mortality" in Economic and Social Commission for Asia and the Pacific Monograph, *Population of Sri Lanka* (Bangkok, 1976).

TABLE 40. AGE-SPECIFIC DEATH RATES BY SEX, 1971, BY ESTATE AND NON-ESTATE SECTORS OF SRI LANKA

Age	*Males*		*Females*	
	Estate	*Non-estate*	*Estate*	*Non-estate*
0-1	102.5	44.1	82.0	37.0
1-4	7.0	5.2	9.1	5.6
5-14	1.5	1.3	1.7	1.3
15-24	1.8	1.8	2.2	1.5
25-34	2.0	2.6	4.1	2.1
35-44	3.3	4.8	5.4	3.1
45-54	7.0	8.9	8.9	5.1
55-64	18.0	17.8	22.9	11.0
65+	138.6	79.8	163.5	77.3

Source: Sri Lanka, computed from data with the Department of Census and Statistics.

TABLE 41. NEONATAL MORTALITY, BY HUSBAND'S OCCUPATION, 1948-1974
(Deaths per 1,000 live births)

Husband's occupation	*All*	*Rural*
Professional, technical, administrative, managerial	22 (1 343)	18 (859)
Clerical	33 (835)	25 (450)
Sales workers	27 (2 178)	25 (1 415)
Self-employed workers in agriculture, animal husbandry, forestry, fishing and hunting	37 (7 714)	35 (7 156)
Non-self-employed workers in agriculture, animal husbandry, forestry, fishing and hunting	63 (3 887)	47 (2 233)
Other service workers	25 (1 677)	20 (1 151)
Skilled production and transport workers	37 (4 476)	39 (3 220)
Unskilled production and transport workers	42 (2 683)	47 (1 948)

Source: S. A. Meegama, "Socio-economic determinants of infant and child mortality in Sri Lanka: an analysis of post war experience", World Fertility Survey Scientific Report No. 8 (London, 1980).

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III. AN INTEGRATION OF DEMOGRAPHIC AND EPIDEMIOLOGIC RESEARCH ON MORTALITY IN KENYA*

*D. Ewbank,*** *R. Henin**** *and J. Kekovole*****

INTRODUCTION

Kenya is unique in sub-Saharan Africa in the rich diversity of its demographic and epidemiologic data. Various researchers have estimated the trends and geographic differentials in mortality, studied socio-economic differentials, examined national-level data on cause of death or measured the importance of various diseases in clinic populations or in small study areas. In 1974, a book entitled *Health and Disease in Kenya* summarized the epidemiologic research on each of the major and many minor causes of death and illness in Kenya (Vogel and others, 1974). It pulls together a wealth of information on many diseases from many varied sources and is an invaluable resource.

The present paper differs from *Health and Disease in Kenya* in several important respects. First, it deals only with important causes of mortality and discusses morbidity only to the extent that many important causes of death are also important causes of illness. Second, it brings together the results of demographic and epidemiologic studies of mortality. This means that greater emphasis is given to overall levels of mortality and to the socio-economic correlates of mortality. Third, and most importantly, the goals of the two works are completely different. The 1974 book attempted to provide an exhaustive review of the epidemiologic research in Kenya. It was organized mostly on a disease-by-disease basis and did not provide an extensive overview that could form the basis for the development of an overall health strategy. The current study, on the other hand, makes no attempt to be exhaustive. Instead it focuses on those issues that are most important for developing a national strategy for reducing mortality. An attempt has been made to pull together the information needed to answer such questions as:

(*a*) Which diseases should be the target of major programme effcrts?

(*b*) Which groups in the population (e.g. which age groups, regions etc.) should be the main targets of programmes?

(*c*) What information is available to guide the design of specific health programmes (e.g. what are the causes of malnutrition)?

(*d*) Which health programmes can be shown to be effective?

In seeking the answers to these questions it has sometimes been discovered that although the data do not provide precise answers, they are sufficient to guide policy. For example, although the authors cannot provide an estimate of the mortality rate due to malnutrition, it is painfully obvious that it is a major cause of death in the population and deserves special emphasis in health planning. In other cases, the current research does not provide adequate answers to many questions that are central to the process of designing programmes. For example, very little information exists on which to base the design of nutrition education programmes for different areas of the country.

It is hoped, therefore, that this study will provide a basis for discussions of the appropriate priorities for health planning in Kenya, for the design of specific programmes, and for selecting topics for future research on the basis of their relevance to health planning.

It is also hoped that this study will be useful to those interested in health planning in other developing countries. Since the health problems in Kenya are in many ways similar to those in other parts of Africa and to developing countries in other areas of the world, the broad outlines that emerge from this study of Kenya are in some ways applicable to other populations. More importantly, we believe that many countries could benefit from similarly broad reviews of their demographic and epidemiologic data on mortality.

Organization of the study

This study includes three major components. The first is the estimation of the levels and trends in mortality for each of the 41 districts. This analysis provides the basis for discussing geographic differentials and for evaluating the reliability and generalizability of epidemiologic data on cause of death. The second component is a review of the studies of the effect of socio-economic and environmental factors and health programme availability on mortality differentials. This section is based largely on the work of demographers using data, on both the dis-

* This report would not have been possible without the contributions of several individuals. First among these is Mr. Henry Mosley, whose efforts were of central importance during the early stages of the project. Ms. Linda Werner was most helpful in the creation of the merged woman file from the National Sample Survey Programme. Messrs. Moses Kibet, Francis Nyamwange, Boniface Koyugi and Pancras Khata of the Population Studies and Research Institute of the University of Nairobi and Jotham Mwaniki of the Population Studies Center, University of Pennsylvania, produced new analyses which are significant contributions to the field of socio-economic determinants of mortality in Kenya.

** Population Studies Center, University of Pennsylvania, Philadelphia, Pennsylvania.

*** Population Studies and Research Institute, University of Nairobi, Kenya.

**** Central Bureau of Statistics, Ministry of Economic Planning and Development, Nairobi, Kenya.

trict and household levels, from censuses and demographic surveys.

The third part of this study is the most unique. It is an attempt to estimate mortality rates by cause for the country and whenever possible to examine geographic differentials or time trends for specific causes of death. The emphasis on mortality reflects the authors' belief that cause-specific and overall mortality rates should be the primary tool used by health planners in developing countries for setting priorities. There are certainly several cases in which examination of incidence and prevalence rates will lead to some changes in priority (for example in areas where schistosomiasis is common), but in most cases, the major health problems in developing countries are the major causes of death.

In order to derive estimates of cause-specific mortality, it is often necessary to make bold assumptions about such variables as case fatality rates or the generalizability of data from small studies or from clinic populations. Because of the limitations of national data on cause of death, the estimates frequently include a range of possible values. Despite these problems it is possible to derive a breakdown of deaths by cause which is accurate enough to establish priorities for health planning.

Cost-benefit-risk analysis of alternative health programmes is beyond the scope of the current research. However, the estimates of cause-specific mortality rates have been combined with rough estimates of the potential impact of specific programmes on various causes to produce crude estimates of the likely programme benefits. Comparisons of likely impact are made for the major causes using several indicators of impact including person-years of life saved, discounted person-years of life saved, and change in life expectancy. In addition, a series of estimates of the effect of various types of programmes on the healthy days of life lived are provided as an illustration of the likely effects of including morbidity in the comparison of programmes.

The final section reviews the most important implications of the findings for health planning.

Sources of data

This integration of demographic and epidemiologic approaches is possible because of the rich diversity of the studies which have been done in Kenya. These include the following major sources of data:

(*a*) *The 1962 population census.* The relevant data from the 1962 census are tabulations of proportions of surviving child by age of mother. These are available for the African population by district based on a 10 per cent sample of rural areas and complete coverage of urban areas. The African population consists of about 97 per cent of the total population;

(*b*) *The 1969 population census.* The 1969 census tabulations give proportions of children dying by age group of mother, district, tribe or nationality, educational attainment and union status. Africans and non-Africans are combined in these tabulations, which complicates comparison with the 1962 census. Tabulations of parental survival (orphanhood) by age and sex of respondent are available at the national level, while tabulations at the district level combine the responses of male and female respondents. These child and parental survival data were collected from 100 per cent of the urban and 10 per cent of the rural respondents;

(*c*) *The 1979 census.* This census included the following topics: relationship to head of household, sex, age, tribe/race or nationality, place of birth, place of residence 12 months before the census, education (years of schooling), survivorship of parents, marital status, number of children ever born by sex, number of deceased children by sex, and date of last live birth and sex of birth.

The above census data have facilitated a comprehensive assessment of infant, childhood and adult mortality levels and differentials on the national level and for administrative areas, and by education and other socio-economic characteristics.

(*d*) *The National Integrated Sample Survey Programme (NISSP).* This Programme was created in 1974 by the Central Bureau of Statistics in order to develop a national multipurpose sample with a permanent administrative structure and staff for field operations, and for data preparation, processing and analysis. The target area covered by the Programme's national sample included all of Kenya except the seven "arid lands" districts, which comprise only about 5 per cent of the total population. The total sample consisted of 31,000 households (23,000 in rural and 8,000 in urban). These were located in 120 rural and 80 urban clusters. The sample was adequate for disaggregation of data into urban/rural breakdowns and into a variety of ecological cropping zones. Among the surveys taken as a part of the Programme that were relevant to this mortality study were: the Integrated Rural Surveys (IRS); the Kenya Fertility Survey (KFS); the 1977 and 1978 National Demographic Surveys (NDS); modules on distances to social amenities, division of labour, labour force, energy, information, education, literacy and nutrition.

There were four rounds of the Integrated Rural Surveys in 1974/1975, 1976/1977, 1977/1978 and 1978/1979 covering 10 per cent of the households in each rural cluster (2,300 households). The core of the questionnaire consisted of the following topics: demographic characteristics of the household and household members, physical description of assets, farm production and disposal.

The 1977 National Demographic Survey covered the entire sample population of the National Integrated Sample Survey Programme (NISSP) (31,000 households) and included information on fertility, child survivorship and parent survival. This survey provided the sampling frame for Integrated Rural Surveys III and IV; thus record linkage is possible through unique household numbers. The 1978 National Demographic Survey again covered the entire sample population with the same schedule.

The 1978 Kenya Fertility Survey covered 10,000 households in the NISSP sample. There were 8,100 respondents, 6,400 of whom were ever-married females. The questionnaire included a comprehensive birth history, with mortality data on all offspring by age at death. Basic social indicators included education of mother and current or last husband's occupation, mother's work history, ethnic group and residence.

(*e*) *Vital statistics registration.* Registration of deaths is carried out by the Registrar General. Although death registration is incomplete, it has been possible to make some inferences regarding causes of death by age, sex and district from these registration data. The registered deaths for 1977 were available on computer tape, which was used to generate cross-tabulations of deaths by cause, age, sex and district which had not previously been available.

(*f*) *Health information statistics of the Ministry of Health.* In 1975 the Ministry of Health introduced a new statistical system for recording inpatient data. All government and most private and mission hospitals in Kenya complete an individual discharge sheet on every inpatient. This includes identifying information, age, sex, occupation, ethnic group, residence, diagnoses, date and status of discharge. These individual discharge sheets are forwarded to the Ministry of Health for processing. By 1977 the system had encompassed almost all the hospitals in Kenya and approximately 600,000 records were being received annually. The data for the years 1977 and 1978 were available on computer tape for the study as detailed later in the report. Detailed statistics on health personnel and facilities by district were also available from annual reports of the Ministry of Health.

A. Socio-economic background

Socio-demographic, geographical, cultural and administrative features

Kenya is a medium-sized country, in surface area 582,646 square kilometres and ranking twenty-second among African countries. Due to favourable environmental conditions, however, some of Kenya's regions are so densely inhabited that the country maintains the tenth largest population in Africa, enumerated at 15.4 million in the 1979 census. Kenya's population growth rate is estimated at 3.8 per cent, total fertility rate at 8.0, infant mortality rate at 84 per 1,000 live births and expectation of life at birth at 57 years. With these rates, the population will reach 20 million in the middle of 1986. Almost half of the population is under age 15 and nearly one quarter is under 6 years of age. Approximately one third is of school age.

Kenya is primarily dependent on agriculture but has a limited supply of agricultural land; 80 per cent of the population lives on the 17 per cent of the land that is suitable for agricultural production. Approximately half of the population is concentrated in 6 per cent of the land; hence the estimated average density of 26 persons per square kilometre for the entire country is misleading. Table 42 sets out the distribution of land and population by district and province. (Map 3 includes the names of each district and province.) In Nyanza, Western and Central provinces, where virtually all the agricultural land is classified as high potential, population densities in 1979 are estimated at 211, 223 and 173 per square kilometre, indicating severe pressure on the land. In some districts, much higher densities are exhibited. As a result the vast majority of Kenyans are small farmers.

Kenya's ethnic mosaic consists of about 70 to 80 tribes, of which there are a dozen major tribes and tribal clusters. Most of the tribes belong to the Bantu, Nilotic and Nilo-Hamitic or Cushitic language groups. At the time of the 1979 census, the Bantu-speaking Kikuyu, Luhya, Kamba, Kisii, Meru, Embu etc. accounted for the majority (66 per cent) of the total population. The Nilotic Luo constituted 13 per cent; Kalenjin, Masai, Turkana, Samburu, Teso, Ndorobo and Njemps formed 15 per cent; and the Nilo-Hamitic (Somali, Rendille, Galla etc.) accounted for an additional 4 per cent of all inhabitants.

These groups generally inhabit their traditional land areas, although land purchases and land resettlement schemes are constantly changing the traditional tribal boundaries. The cities are characterized by an ethnic mixture. The Bantu, the Luo and the Kalenjin, all agriculturalists, are found in the Highlands, the Lake Victoria Basin and some areas of the coast. The pastoral Masai inhabit the south-eastern plains, and the nomadic Somali, Rendille and Galla roam Kenya's arid north-east. Non-Africans—immigrants or descendants of immigrants from South Asia, the Middle East and Europe—accounted for less than 2 per cent of the total population.

Kenya is divided into seven major administrative areas, known as provinces. Each province is further subdivided into districts (map 3), divisions, locations and sublocations. The Nairobi area has a special provincial status.

Economic and social policies and trends

Since independence in 1963, Kenya has achieved substantial progress in terms of overall economic development. Throughout the 20 years the Government has adopted social and economic policies to alleviate problems related to hunger, ignorance and disease by enhancing equal opportunity for all citizens, and a high and growing per capita income has been equitably distributed.

The development strategy has accorded first priority to the development of the rural areas, where 85 per cent of Kenya's population live. Even though the rate of economic growth has fluctuated over the years, it has been on average quite impressive. The annual growth rate in the GDP between 1964 and 1972 was 6.5 per cent, between 1972 and 1977 it was 4.7 per cent and it was projected to be 6.3 per cent during the development plan of 1979-1983. Overall, the development achieved in agriculture, education and health has been substantial.

In the following paragraphs some policies and developments achieved in these sectors (agriculture, health, education, nutrition and water) are highlighted.

Agricultural policies. As mentioned before, agriculture is the mainstay of the Kenyan economy, contributing almost one third of the GDP. More than 80 per cent of the population are dependent on agriculture for their livelihood. The major policy related to agricultural development has been the promotion of small-scale farming. Thus a considerable amount of land previously used for large-scale farming has been subdivided. A few large farms have been left intact to ensure sufficient supplies of wheat, seed, maize and livestock, which can best be produced on a large scale.

TABLE 42. DISTRIBUTION OF POPULATION AND POPULATION DENSITY BY DISTRICT AND PROVINCE, KENYA, 1969 AND 1979

	Percentage of total population		*Population density per sq. km*			
Province/district	*1969*	*1979*	*Total 1969*	*Total 1979*	*Arable 1969*	*Arable 1979*
Nairobi	4.7	5.4	745	1 210	–	–
Central	15.4	15.3	127	173	131	254
Kiambu	4.3	4.5	184	290	260	375
Kirinyaga	2.0	1.9	146	202	201	270
Muranga	4.1	4.2	176	261	213	310
Nyandarua	1.6	1.5	54	66	67	88
Nyeri	3.3	3.2	108	148	226	304
Coast	8.6	8.8	11	16	823	1 173
Kilifi	2.8	2.8	25	34	88	123
Kwale	1.9	1.9	25	34	72	100
Lamu	0.2	0.3	4	6	7	13
Mombasa	2.3	2.2	1 155	1 662	–	–
Taita	1.0	1.0	6	8	213	284
Tana River	0.4	0.6	1	2	39	71
Eastern	17.4	17.7	12	17	71	101
Embu	1.6	1.7	62	96	71	104
Isiolo	0.3	0.3	1	1	–	–
Kitui	3.1	3.0	11	15	28	39
Machakos	6.5	6.7	50	72	79	114
Marsabit	0.5	0.6	1	1	1 300	2 405
Meru	5.4	5.4	63	83	178	247
North-Eastern	2.3	2.4	2	2	–	–
Garissa	0.6	0.8	1	2	–	–
Mandera	0.9	0.7	4	3	–	–
Wajir	0.8	0.9	2	2	–	–
Nyanza	19.4	17.3	163	211	169	211
Kisii	6.2	5.7	307	396	307	396
Kisumu	3.7	3.2	193	232	193	232
Siaya	3.5	3.1	151	188	151	198
South Nyanza	6.0	5.3	114	143	116	143
Rift Valley	20.2	21.1	13	19	70	103
Baringo	1.5	1.3	15	20	65	82
Elgeyo Marakwet	1.5	1.0	57	65	153	143
Kajiado	0.8	1.0	4	7	391	677
Kericho	4.4	4.1	97	161	126	167
Laikipia	0.6	0.9	7	13	52	103
Nakuru	2.7	3.4	40	90	88	153
Nandi	1.9	1.9	75	109	89	128
Narok	1.1	1.4	7	13	14	23
Samburu	0.6	0.5	3	4	40	55
Trans Nzoia	1.1	1.7	50	124	60	125
Turkana	1.5	0.9	2	2	1 375	1 189
Uasin Gishu	1.7	2.0	50	89	58	92
West Pokot	0.8	1.0	16	17	80	154
Western	12.1	12.0	162	223	179	147
Bungoma	3.2	3.3	113	163	136	199
Busia	1.8	2.0	119	183	123	183
Kakamega	7.1	6.7	220	294	241	317
Kenya	100.0	100.0	19	27	1 102	155

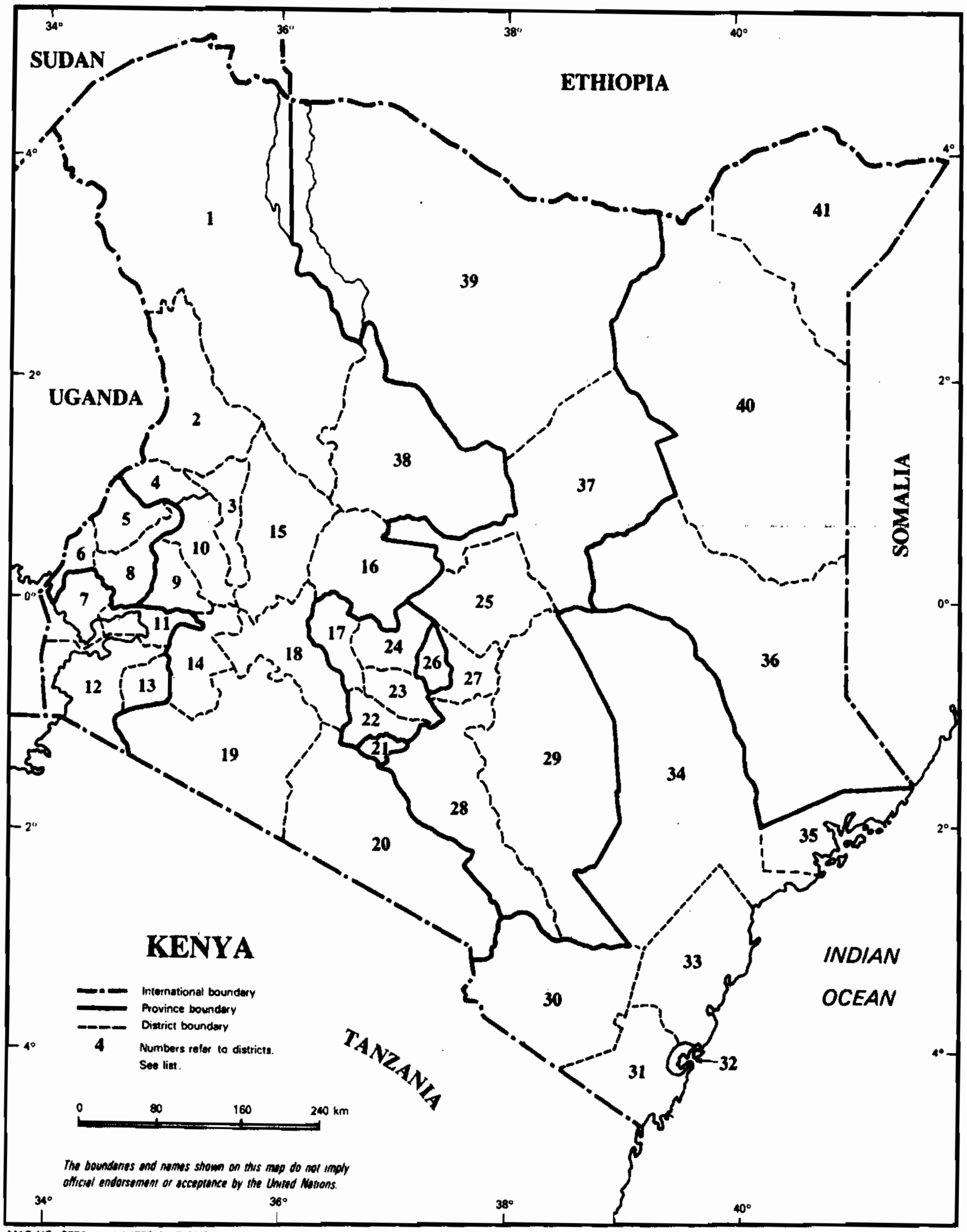
Source: Statistical abstract 1979 and population censuses of 1969 and 1979.

During the first decade after independence, Kenya's agricultural output doubled and the contribution made to overall growth and welfare was significant. The sector began to slacken in performance during the mid-1970s due to bad weather and low prices secured for agricultural exports. During this period the initial goals of sustained social and economic progress, particularly distribution goals related to employment and income distribution, were not achieved. The development plan of 1979-1983 aimed at enhancing the role of agriculture in the economic development of the country by improving agricultural methods as well as its comparative advantage in relation to other sectors of the economy.

Health policies and trends. The provision of health services has been accorded the requisite significance by the Kenya Government. By 1978 expenditure on health services comprised 6 per cent of the budget. The major objectives for accelerated development of health services since independence have been:

(*a*) Strengthening and carrying out measures for the eradication, prevention and control of disease; such measures include protection of the environment against health hazards, vector disease control, immunization against disease, early detection and treatment of diseases and health education;

Map 3. Districts and provinces of Kenya



MAP NO. 3334 UNITED NATIONS
SEPTEMBER 1985

MAP KEY

Nairobi 21

Central province
- Kiambu 22
- Kirinyaga 26
- Muranga 23
- Nyandarua 17
- Nyeri 24

Coast province
- Kilifi 33
- Kwale 31
- Lamu 35
- Mombasa 32
- Taita 30
- Tana River 34

Eastern province
- Embu 27
- Isiolo 37
- Kitui 29
- Machakos 28
- Marsabit 39
- Meru 25

North-Eastern province
- Garissa 36
- Mandera 41
- Wajir 40

Nyanza province
- Kisii 13
- Kisumu 11
- Siaya 7
- South Nyanza 12

Rift Valley province
- Baringo 15
- Elgeyo Marakwet 3
- Kajiado 20
- Kericho 14
- Laikipia 16
- Nakuru 18
- Nandi 9
- Narok 19
- Samburu 38
- Trans Nzoia 4
- Turkana 1
- Uasin Gishu 10
- West Pokot 2

Western province
- Bungoma 5
- Busia 6
- Kakamega 8

(*b*) Provision of adequate and effective diagnostic, therapeutic and rehabilitative services for the whole population offered at hospitals, health centres, dispensaries and mobile units;

(*c*) Promotion and development of biomedical and health services research as a means of identifying improved cost-effective methods for the protection of the health of the population.

The major deficiencies of the health sector have been:

(*a*) Inadequate and uneven coverage of the population due to insufficient health service delivery points and the underutilization of some of the existing facilities;

(*b*) Shortages of medical manpower due to severe shortages of trainers in the health field;

(*c*) Unsatisfactory patterns of utilization of manpower: The majority of staff are deployed in urban areas and in major hospitals—with Kenyatta National Hospital spending a substantial proportion of current expenditure;

(*d*) Unsatisfactory utilization of equipment and transport because of financial and managerial problems relating to operation and maintenance;

(*e*) Shortages of drugs and other essential supplies due to financial constraints and an inefficient distribution system;

(*f*) Inadequate flow of health information and utilization of the available information.

Table 43 sets out the number of health institutions and hospital beds and cots by province in 1981. The uneven distribution of these facilities is demonstrated by the variation in the number of hospital beds and cots per capita from 720 in Nairobi to 91 in North-Eastern province.

Education policies and trends. The Government has continued to give high priority to educational development. The share of recurrent expenditure on education has been maintained at about 30 per cent since independence. Free primary school education (first seven years of school) has been granted to the eligible population. Efforts to increase educational facilities and to improve the quality of education have been expended to develop the skills necessary for income-earning opportunities. The primary school enrolment ratio has increased from 88 per 100 of school-age population in 1975 to 96 in 1980. The enrolment ratios have varied from district to district, the lowest recorded ratios being those for sparsely populated districts inhabited by nomadic populations. On the average the trend in the primary school enrolment ratio has been upward.

Nutrition policies. The importance of food and nutrition has been recognized by the Government since the first development plan (1974-1978) and has been given more emphasis in the current development plan (1979-1983). It has been observed that even though there is sufficient food in Kenya to satisfy the nutritional requirements of the population, nutritional problems have persisted due to inequalities in purchasing power and in supply between districts and seasonal variations in availability. This is particularly the case among vulnerable groups such as pre-school children and pregnant and lactating mothers. National nutrition surveys have pinpointed protein energy malnutrition (PEM) as a major problem. Government policy in recent years has achieved some degree of success in the nutrition area. Some of this success has been an indirect outcome of higher food production, increased farm incomes and improved food marketing.

Policies related to availability of water. The quantity and quality of water are an important determinant of the health status of the population. Policies have been stipulated to accelerate the provision of potable water to the population in both urban and rural areas. As shown in table 44, a significant proportion of rural households had some source of water within a radius of less than two kilometres in 1976. The major sources of water were streams and springs.

Other social indicators. Table 44 also provides other important social indicators that have some bearing on mortality. The distances to primary schools, health facilities, markets, means of lighting and roads are crucial in facilitating their utilization by the population.

TABLE 43. HEALTH INSTITUTIONS AND HOSPITAL BEDS AND COTS BY PROVINCE, KENYA, 1981

Province	*Health institutions*				*Hospital beds and cots*	
	Hospitals	*Health centres*	*Health sub-centres, dispensaries*	*Total*	*Number of beds and cots*	*Number per 100,000 population*
Nairobi	17	8	62	87	6 253	720
Central	45	38	180	263	4 351	179
Coast	24	22	133	179	2 930	211
Eastern	27	27	193	247	3 827	136
North-Eastern	3	3	18	24	354	91
Nyanza	38	39	142	219	2 937	109
Rift Valley	52	86	363	501	4 987	147
Western	15	39	39	93	2 469	130
TOTAL 1981	221	262	1 130	1 613	28 108	177
TOTAL 1966	177	160	432	769	12 438	129

Source: Data provided by the Central Bureau of Statistics.

TABLE 44. PERCENTAGE OF HOUSEHOLDS BY SELECTED SOCIAL INDICATORS AND PROVINCE, KENYA, 1976-1977

Social indicator	*Coast*	*Eastern*	*Central*	*Rift Valley*	*Nyanza*	*Western*	*Total*
With water							
Piped	42	8	21	15	13	2	14
On holding[a]	28	27	67	62	41	66	51
Within 2 km[a]	13	38	21	15	27	13	24
Primary school within 2 km	50.9	77.7	81.7	58.9	76.0	82.9	73.2
Health centre within 2 km	4.7	11.9	14.1	16.4	18.1	21.1	15.5
Local market within 2 km	17.7	29.2	31.9	24.4	54.5	67.4	38.9
Electricity in main dwelling unit	5.6	1.2	0.5	1.7	0.8	0.5	1.2
Bus/Matatu route within 2 km	31.5	42.7	50.1	44.7	45.3	52.5	45.8

Source: Data provided by the Central Bureau of Statistics.

[a] During dry season.

Most people in 1976 indicated that they had to travel at least two kilometres to get to the nearest health centre, market and road. The proportion of households with electricity is insignificant in all provinces (the proportion for Coast province is affected by the inclusion of an unrepresentative number of clusters with access to urban facilities).

A summary of the findings for the female population from the literacy survey conducted in 1980 is provided in map 4. Almost 48 per cent of the population was able to read. The rates by province range from 39 per cent in Nyanza to 65 per cent in Central province for the sexes combined. The male and female literacy rates (the proportion who can read) were estimated at 62 and 38 per cent, respectively.

B. MORTALITY LEVELS AND TRENDS

Introduction

Kenya has an unusually rich set of national-level demographic data which allow estimation of mortality rates for about the last 30 years. Earlier data (before around 1950) were based on crude estimates for small areas collected during the 1920s and 1930s for other purposes. At the time of the 1948 census, mortality was starting to decline and Kenya was in the first stage of the demographic transition. The census asked women over age 16 to report the number of children they had ever had and the number who had died before age 1 year. This led to an estimated infant mortality rate of 184 per 1,000 live births. Early analysts considered this to be an unreasonably high estimate and therefore assumed that women may have reported children who died before weaning (Martin, 1953), at about 18 months of age. However, the analysis in the following pages suggests that this is a reasonable estimate of infant mortality in the 1940s.

The 1962, 1969 and 1979 censuses provide a more complete picture of mortality. These censuses give data on children ever born and children surviving for women in each five-year age group for each district. The 1969 and 1979 censuses also provide data on maternal and paternal orphanhood for each district. In addition, the fertility surveys all provide some data on child mortality. The most useful of these is the Kenya Fertility Survey (KFS). Analysis of the data from these sources suggests that by 1979 the infant mortality rate had declined to about 84 per 1,000 births and the life expectancy at birth had reached about 56 years. These values place Kenya in an intermediate position between the high levels still found in many other parts of Africa and the low mortality levels of the developed countries. However, the overall estimates of mortality mask major variations within the country.

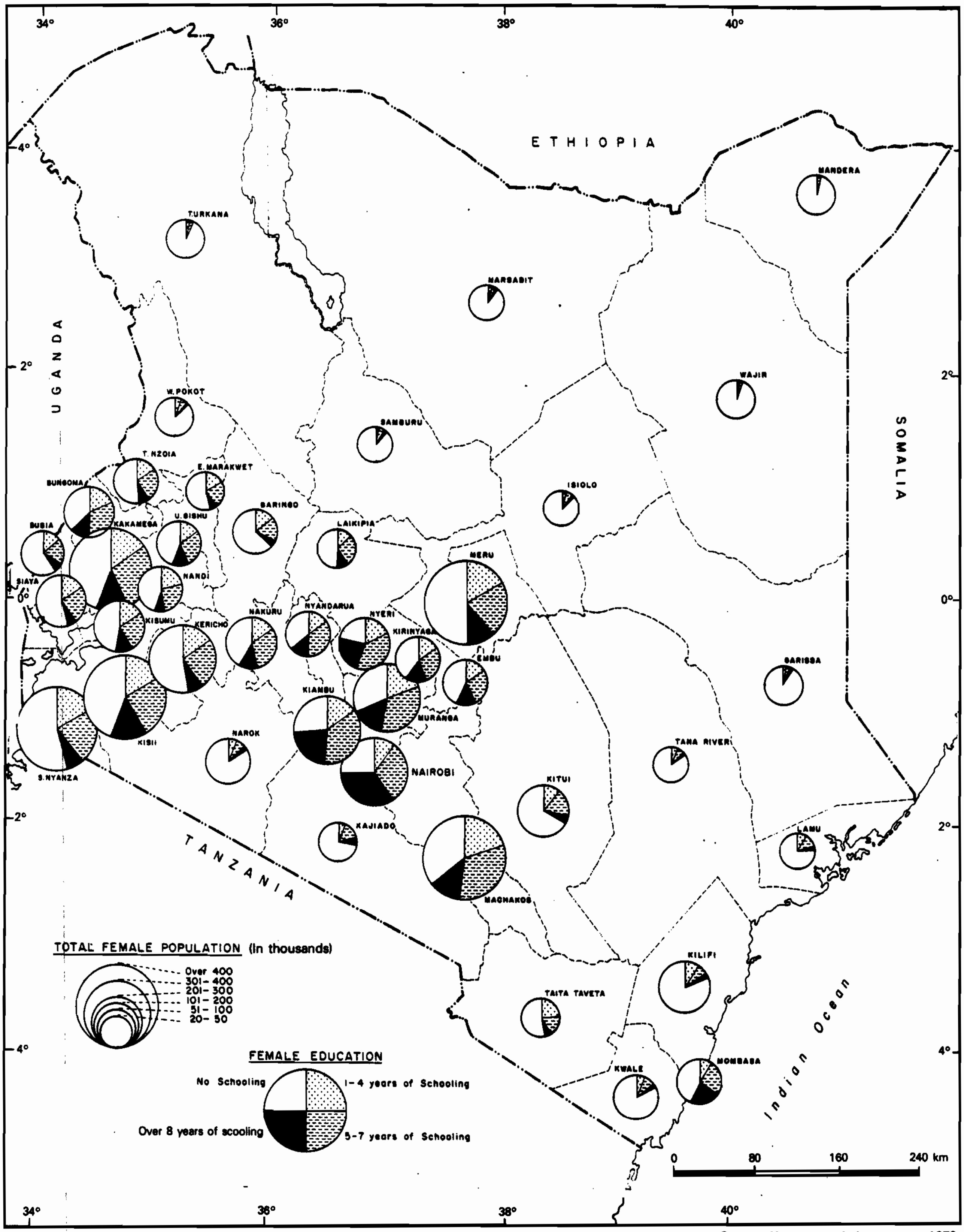
The discussion that follows reviews national and district estimates of infant, child and adult mortality, trends in mortality and estimates of the age patterns of mortality. The appendix outlines the sources of the estimates, which are the result of an extensive re-evaluation of procedures for studying mortality when data are available from several sources. These estimates are probably more accurate than any other national and regional estimates available for any part of sub-Saharan Africa not covered by complete vital registration.

National mortality levels and trends

The infant mortality rate in Kenya declined from about 180 per 1,000 live births in the mid-1940s to 125 in 1959, 105 in 1969 and 84 in 1979 (see table 45). This represents a decline of about 20 per cent per decade for the last 20 years. Since the child survival data provide estimates of the average mortality rate for a period of years,* it is not possible to examine the effect on the rate of decline of such events as independence or changes in the national health system.

* The Brass method for estimating child mortality from data on child survival provides estimates for the period during which the interviewed women have been bearing children. For example, the data for women aged 20-24 provide an estimate of mortality for the period which begins about 10 years before the survey (when the oldest women began childbearing) and ends at the date of the survey. The estimates for older women apply to a longer time period since their children have been born over the past 25 to 35 years. For the analysis of trends, one date is found to which each estimate applies.

Map 4. Percentage of females with various levels of education, by district, Kenya



3335.1x

Source: Kenya population census, 1979.

Source: Kenya population census, 1979.

TABLE 45. ESTIMATES OF THE INFANT MORTALITY RATE, EXPECTATION OF LIFE AT BIRTH, AND CRUDE DEATH RATE, DISTRICTS OF KENYA

	Infant mortality rate (per 1,000 live births)			*Life expectancy at birth*		*Crude death rate*
Province/district	*1959*	*1969*	*1979*	*1965*	*1979*	*1977*
Nairobi[a]	(82)	(71)	(61)	(57.9)	(62.1)	(7.1)
Central	101	66	45	57.2	66.9	8.7
Kiambu	96	64	42	58.5	68.3	7.4
Kirinyaga	121	84	58	52.2	62.6	10.8
Muranga	111	72	46	55.7	67.0	9.4
Nyandarua	96	63	52	58.8	65.4	8.4
Nyeri	84	52	38	59.4	67.6	8.2
Coast	149	131	123	48.7	51.8	15.6
Kilifi	161	155	149	45.6	46.9	19.3
Kwale	155	146	137	46.2	48.2	17.8
Lamu	117	130	144	48.5	45.3	19.2
Mombasa[a]	(100)	(91)	(83)	(54.9)	(57.3)	
Taita/Taveta	184	126	84	48.9	60.5	11.2
Tana River	147	137	128	46.7	48.8	16.9
Eastern	119	91	71	52.8	59.7	12.0
Embu	116	83	59	53.0	62.1	11.1
Isiolo	181	166	153	38.9	41.5	22.6
Kitui	156	126	100	48.6	55.5	14.7
Machakos	130	97	72	54.8	63.1	10.5
Marsabit	95	95	95	53.8	53.8	15.9
Meru	76	63	52	53.5	58.5	11.9
North-Eastern	128	117	105	49.8	53.4	13.2
Garissa	103	103	103	51.7	51.7	12.8
Mandera	110	110	110	52.6	52.6	13.6
Wajir	178	136	103	45.2	53.8	13.4
Nyanza	164	149	115	43.0	51.0	16.6
Kisii	122	92	69	50.4	58.3	11.5
Kisumu	193	162	135	39.4	45.3	19.6
Siaya	220	181	147	39.4	46.2	21.6
South Nyanza	223	180	143	39.7	47.3	18.5
Rift Valley	102	87	74	54.0	58.2	11.6
Baringo	121	121	121	48.1	48.1	17.6
Elgeyo Marakwet	93	93	93	54.2	54.2	14.2
Kajiado	98	88	79	54.7	57.8	12.0
Kericho	84	67	53	56.5	62.5	9.5
Laikipia	90	67	50	56.0	63.2	9.9
Nakuru	113	85	64	54.9	62.8	10.0
Nandi	90	75	74	54.7	56.5	13.5
Narok	76	71	65	55.6	58.1	12.0
Samburu	86	74	64	58.1	62.0	10.1
Trans Nzoia	136	106	81	53.6	61.1	10.5
Turkana	113	113	113	49.2	49.2	12.9
Uasin Gishu	98	79	64	56.0	61.8	10.0
West Pokot	180	156	135	43.3	47.9	18.1
Western	152	122	105	47.9	54.8	15.2
Bungoma	131	105	84	50.0	56.8	13.2
Busia	198	164	135	40.1	46.4	19.6
Kakamega	148	118	107	48.9	53.3	15.1
TOTAL	125	105	84	51.0	57.4	12.7

Source: See annex.

[a] Values for Nairobi and Mombasa are inexact and are only used for calculating totals.

The census estimates of the declines in mortality at ages 1 to 4, *m*(1-4), are not independent of the estimates for the infant mortality rate and therefore it is not possible to use them to demonstrate any differences in the rate of decline of infant and child mortality. The Kenya Fertility Survey maternity history data for births to women aged 20-29, however, are completely consistent with the census estimates of trends in infant and child mortality, so it appears that the age pattern of child mortality has not changed in the last 20 years. The census estimates show that $m(1\text{-}4)$ declined from about 24.1 per 1,000 population in 1959 to 19.6 in 1969 and reached 16.0 in 1979.*

The 1969 and 1979 censuses provide data on the survival of each person's mother and father by district. These data are our best source of information on adult mortality levels although they provide only rough estimates. The 1969 district data were not published by sex of respondent and do not seem to be as reliable as those collected in 1979. The most reliable estimates of adult mortality are those based on the responses of women aged about 30-49 in 1979 which apply to the period 1965-1969. Parental survival data provide an estimate of survival from the mean age at childbearing, M, to the mean age of childbearing plus the mean age of respondents. Therefore it is necessary to estimate the proportion surviving to the mean age of childbearing in order to estimate the life table values at the older ages. This has been accomplished by estimating the proportion surviving to age M, 1_M, from the child survival estimate of 1_{20}.

When linked at the district level with child mortality estimates for the appropriate year, the data suggest a life expectancy at age 20 (e_{20}) of about 45.9 years in 1965. The 1969 census data suggest a value of 44.0 years in 1955. An examination of the changes in the percentage orphaned for the nation between 1969 and 1979, using a new intercensal orphanhood method proposed by Preston (1983), suggests a value of e_{20} of 47.8 for 1974. Extrapolating these trends forward we estimate that in 1979 e_{20} was about 49.0 years.

When the estimates of infant and child mortality are linked with the parental survival data for each district, the resulting estimates of life expectancy at birth are 45.9 for 1955 and 50.1 for 1965. Linking the national estimate of e_{20} of 49 in 1979 with the national estimate of child survival leads to an estimated life expectancy at birth, e_0, for 1979 of 57.4.

Regional variations in mortality

The geographic pattern of infant mortality rates in 1979 is shown in map 5 and table 45. In 1979, the highest infant mortality rate (149 in Kilifi) was about four times as high as the lowest rate (38 in Nyeri). In general, high mortality is estimated for the high-density populations near the lake and on the coast, while the districts to the north of Nairobi have very low levels. The less densely populated districts show intermediate levels of mortality. The rates for a few districts in the northern part of the country (particularly Samburu and Turkana) may be understated because of under-reporting of deceased children. However, there are no data for these districts that are more reliable than the census data, so it is not possible to produce more reliable estimates.

The mortality estimates for Nairobi and Mombasa are necessarily very crude because of the nature of the estimation procedures. The data on child survival for the cities is not limited to children born in the city or to person-years of risk lived in the city, but includes some children who may have died in other areas before their mother migrated to the city. The census child survival estimates, maternity histories from the Kenya Fertility Survey and the registered deaths all suggest an infant mortality rate for Mombasa of about 80-85. The estimates for Nairobi are much less consistent, ranging from 41 to 80. The estimated values for the two cities for 1979 (55 for Nairobi and 80 for Mombasa) are therefore rough approximations.

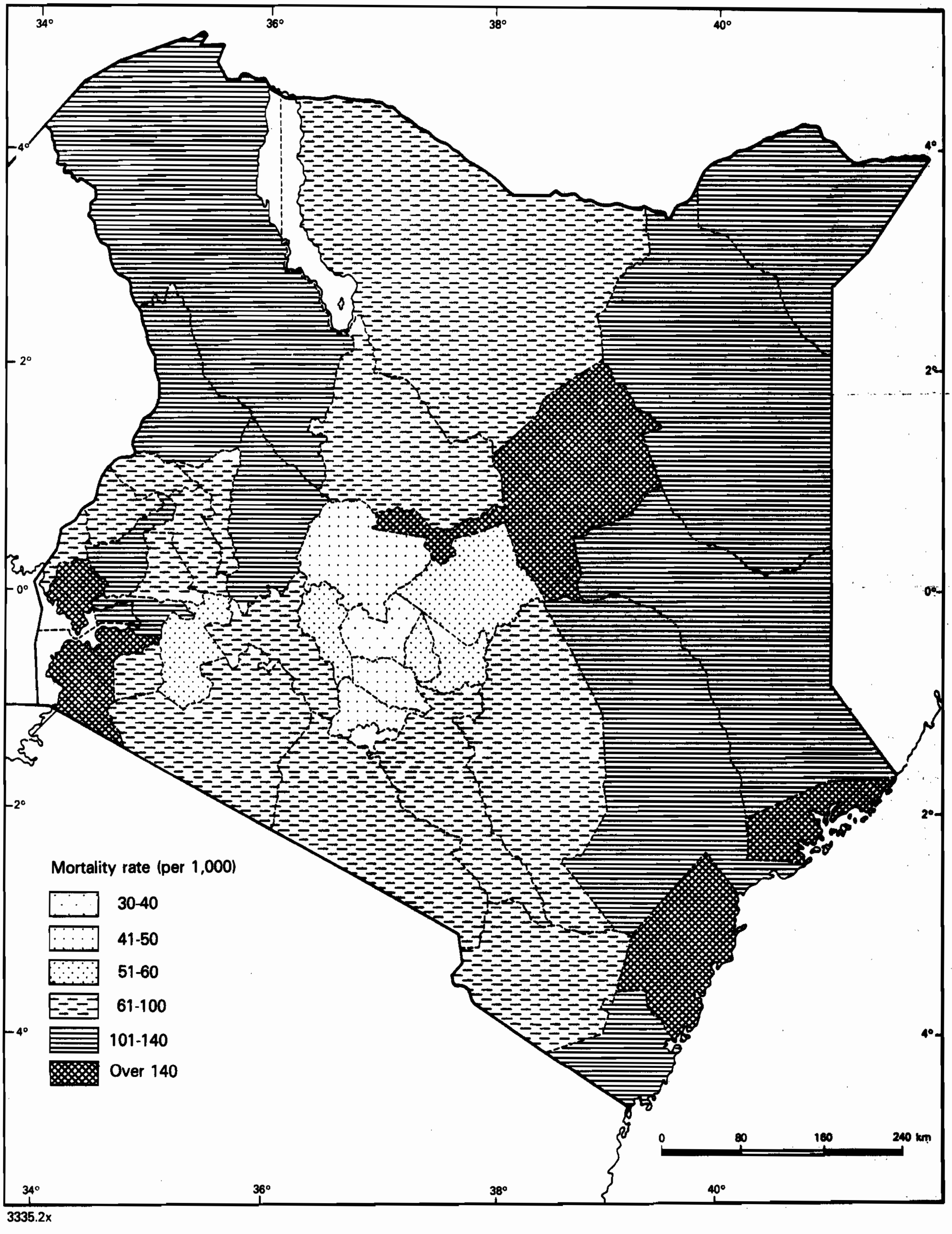
The Kenya Fertility Survey provides some insight into the geographic pattern of neonatal mortality. The neonatal mortality rate for the whole country for the period 1967-1977 reported in the maternity histories was 39.8. However, two provinces, Coast and Western, showed values which are substantially higher than the neonatal rates for the other provinces. The rate for Coast was 67.4 (70 per cent above the national rate), while the rate for Western province was 50.7. As we shall see later, the high neonatal mortality rates for these two provinces may be related to the level of neonatal tetanus.

Map 6 presents the geographical patterns of infant mortality declines between 1959 and 1979. While several districts in and around Central province had declines of 30-35 per cent, some other districts had little decline in mortality. In particular, although the lake and the coastal areas have similar infant mortality levels today, this has not generally been the case. In 1959, Kisumu, Siaya and South Nyanza had infant mortality rates of about 190-225, and the coastal districts of Kilifi and Kwale had rates of about 160. While the lake districts have had substantial declines in infant and child mortality, the coastal districts have had little or no decline. A comparison of the 1962, 1969 and 1979 censuses for these districts suggests either no decline over the period 1965-1977 or under-reporting of deceased children in 1969. In either case, it is clear that the similarity between the lake and the coastal areas in their current infant and child mortality rates is a coincidence. While the lake areas have experienced a substantial decline, the coastal areas have seen little or no improvement.

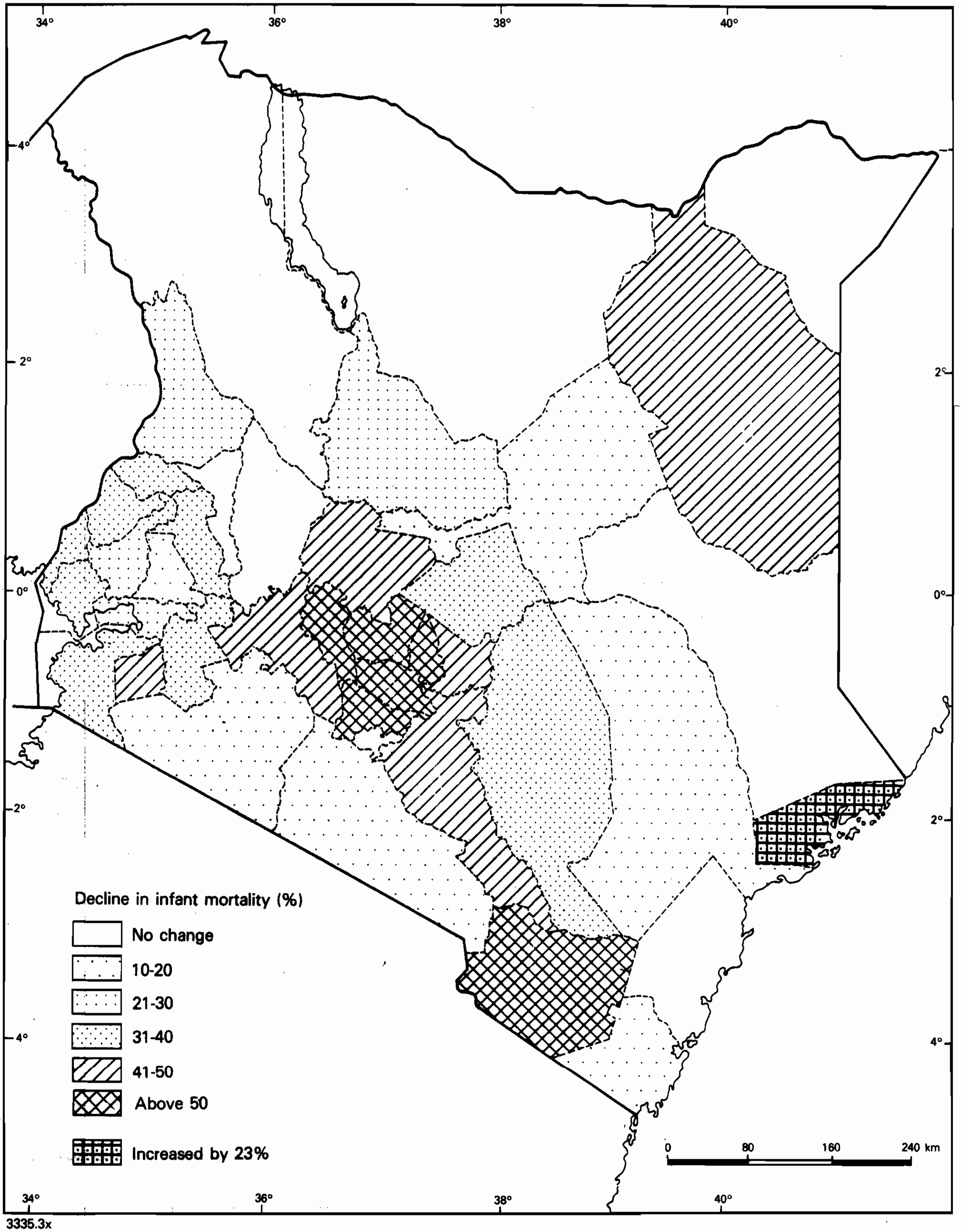
Data from a survey conducted in six communities by the East African Medical Survey from 1951 to 1955 (Brass, 1959) lend support to the estimates of mortality differences between the lake area and the coast. Two of the six selected communities were in Kenya: one in Kisii in South Nyanza district and one, Msambweni, in Kwale district. The mortality data include the number of children ever born, the number of living and currently under the age of 5 and the number deceased before age 5. A mortality rate for ages 0-4 can be estimated by assuming that those living children under age 5 are on the average 2.5 years old and that those who died under age 5 died on the average at 1 year of age. This leads to an estimated central death rate of 114 per 1,000 for the Kisii area and 77 for the area in Kwale. These estimates sug-

* It is not possible to use the Kenya Fertility Survey maternity histories to get direct estimates of mortality trends. The reason for this is that since the sample was limited to women under the age of 50 at the time of the survey, the infant mortality estimates for early periods are limited to births to young women. However, the mortality rates reported for births to women in the age group 20-29 provide a reasonable estimate of the pattern of mortality decline. The data suggest a slightly faster decline than the census estimates. While the census data suggest that between 1960 and 1975 the infant mortality rate declined by 25 per cent and the $m(1\text{-}4)$ by 26 per cent, the Survey estimates are 31 per cent and 32 per cent. Since the census and the estimates of the infant mortality rate for the five years preceding the Kenya Fertility Survey are very similar, the difference between the trends from the two sources is a difference in the mortality estimates for the period around 1960.

Map 5. Kenya infant mortality rate, 1979 census



Map 6. Infant mortality change in Kenya, 1959-1979



gest infant mortality rates of about 240 and 160, respectively, which are consistent with the census data for these areas.* Although these data are limited in terms of both geography and detail, they clearly suggest substantial mortality differences between the two areas.

Map 7 presents the district estimates of life expectancy at age 20 (e_{20}) for 1965 and table 45 gives district, provincial and national estimates of life expectancy at birth, e_0, for 1965 and 1979 and the crude death rate for 1977. The appendix provides life tables for each province for 1979.

Sex differentials in mortality

The 1979 census provides data on child survival by sex which can be used to estimate the sex differential in infant and child mortality. These data suggest that the infant mortality rate for males is about 89 while the rate for females is about 81. These sex differentials are small compared with those found in other populations (United Nations Population Division, 1983). This differential is similar in all of the provinces and suggests that the sex differentials in infant and child mortality are largely determined by inherent biological differences between the sexes rather than by cultural practices which lead to differential child care for sons and daughters. This conclusion is consistent with the 1977/1978 nutrition survey which found no difference between the nutritional statuses of boys and girls when they were compared with sex-specific standards based on United States children. The major exception to this generalization about sex differences in infant and child mortality is Turkana district, which reported excess mortality among females.

Sex differentials in adult mortality have been studied by comparing estimates of the sex differentials using parental survival data from the 1969 and 1979 censuses. This comparison shows that the female advantage in adult mortality increases as the level of mortality declines. Each one-year increase in e_{20} leads to an increase in the female advantage in e_{20} of approximately 0.6 years. This is reflected in the final mortality estimates, which include an increase in the national female advantage in e_{20} from 2.5 years in 1955 to 3.8 years in 1979.

Several districts have unusual sex differentials in adult mortality. The most interesting case is that of Turkana, which has a male advantage in e_{20} of about 1.4 years for 1965. This finding reinforces the finding of excess female mortality among infants and children. Wajir shows a similar, though much smaller, male advantage of about 0.3 years. All of the other districts show a female advantage. The unusually high sex differentials in Isiolo (a female advantage of 4.6 years) suggest errors in the data which were apparent at other points of the analysis.

All of the districts of Nyanza province show a higher female advantage in e_{20} than is found in other districts at similar levels of mortality. For example, a regression on the four districts in Nyanza province gives:

$$e^f_{20} - e^m_{20} = -20.78 + 0.587\, e_{20}$$

A similar regression for all other districts except Turkana, Wajir and Isiolo gives:

$$e^f_{20} - e^m_{20} = -25.77 + 0.627\, e_{20}$$

Therefore, at a value of e_{20} of 42 years, which is typical for Nyanza province, we would expect a female advantage of (0.587·42 − 20.78) or about 3.9 years in Nyanza and only 0.6 years elsewhere. It is not clear why Nyanza province should show an unusually large female advantage; data errors, cultural practices and aggravation of sex differentials by environmental factors are all possible causes. However, the estimated difference between Nyanza and the rest of the country is large enough that it is not likely to be a result of reporting errors, and environmentally Nyanza is not that different from some other areas. Therefore, this sex differential probably reflects cultural practices.

When the sex-specific estimates of infant and child mortality are linked with the estimates of adult mortality, we estimate that the female advantage in e_0 has increased from about 3.0 years in 1955 to about 3.7 years in 1979.

C. Determinants and correlates of mortality

Introduction

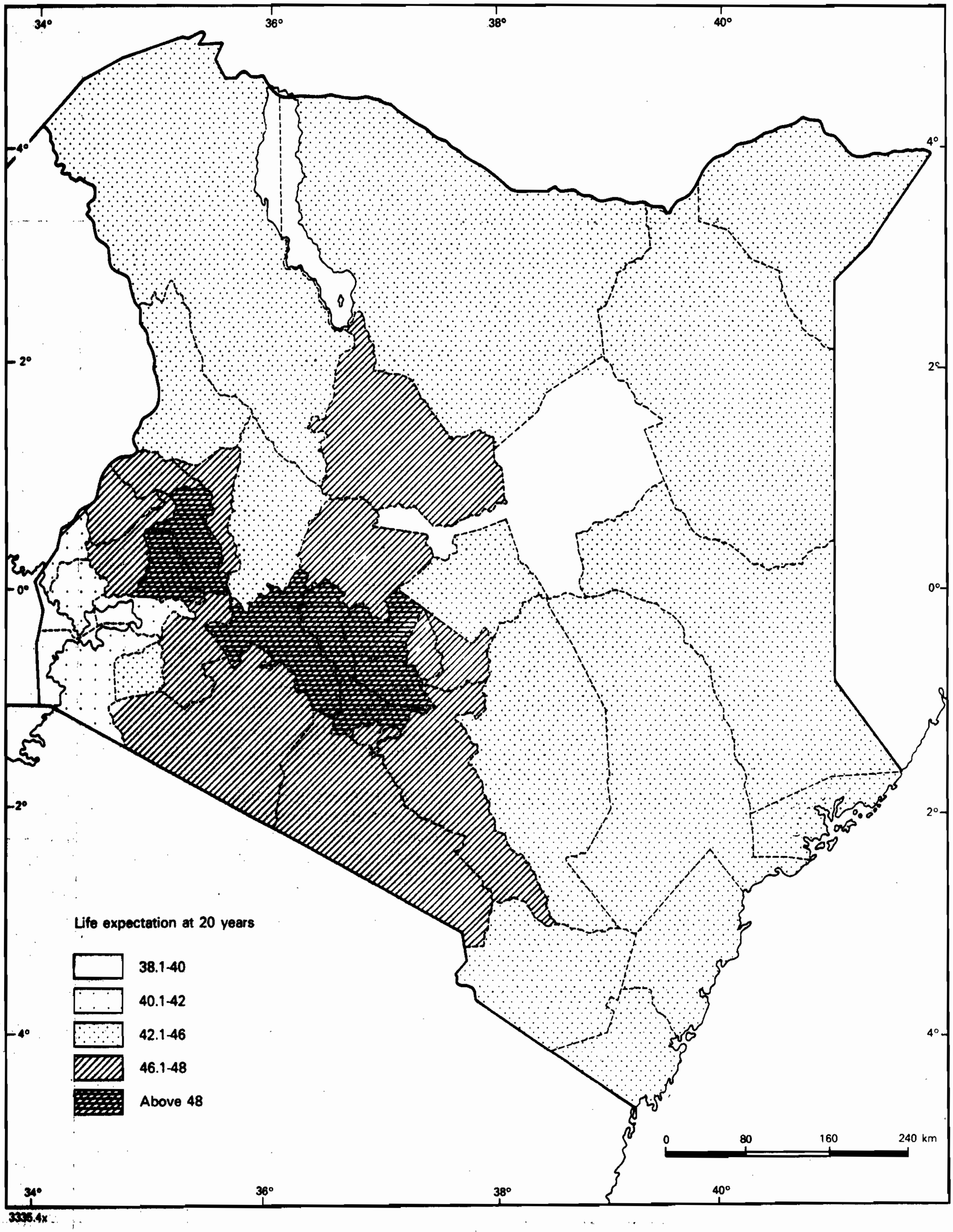
Determinants of mortality trends and differentials can be usefully separated into social and economic factors, environmental factors (e.g. types of agriculture and prevalence of malaria), demographic factors (maternal age, length of inter-birth intervals etc.) and health services. Although the effects of these factors are clearly interrelated, they are often associated with different strategies for reducing mortality. This section reviews the evidence on the effect of each of these four sets of factors on mortality in Kenya. Emphasis is placed on infant and child mortality since that is where the data are prevalent.

Two different approaches were taken to the study of the correlates of mortality differentials. The first approach relates district estimates of mortality to other characteristics of the districts. This approach has been applied to infant mortality estimates for 1969 and 1979, to the change in infant mortality between 1969 and 1979, and to the estimated expectation of life at age 20 for 1965. The second approach relates data on the survival of a woman's children to her characteristics and the characteristics of her household. This second approach has been applied to the Kenyan Fertility Survey (KFS) by Mwaniki and to the National Demographic Survey (NDS) of 1977 linked with the Integrated Rural Survey III (IRS3) by Khata. Thus mortality differentials have been examined both at the macro (district) level and at the micro (household) level. The results from these studies are compared below with the results from other studies of mortality differentials in Kenya.

The following sections outline the various approaches in detail, including a description of all of the variables considered in each analysis. Following the description of the methods, the conclusions regarding the relationships between each variable (e.g. education, health facilities,

* These infant mortality rate estimates are based on North model life table number 11 transformed by a logit slope of 0.9, which is consistent with the data for these areas for later periods.

Map 7. Life expectation at age 20, Kenya



maternal age etc.) and mortality are discussed one at a time.

Mortality differentials among districts

The district mortality estimates presented in table 45 have been used to examine the correlates of mortality differentials among districts. The regression on 1979 infant mortality rates included female literacy, the prevalence of malaria, the percentage urban, the number of kilometres of road, population density, and the potential agricultural land per capita. A measure of the availability of health services was constructed by taking the per capita availability of beds in hospitals and dispensaries divided by the square root of the land area of the district. This provided a crude measure of accessibility which should be superior to the more frequently used per capita availability. Also included were a series of variables which assigned each district to an ecological zone to test for regional differences in mortality. The five zones were: (*a*) the lake basin around Lake Victoria (the districts of Bungoma, Busia, Kakamega, Kisii, Kisumu, Siaya and South Nyanza), (*b*) the dry areas of the Rift Valley (Baringo, Elgeyo Marakwet, Laikipia, Nakuru, Narok and Nyandarua), (*c*) the fertile highlands (Kericho, Nandi, Trans Nzoia and Uasin Gishu), (*d*) the Mount Kenya area (Embu, Kiambu, Kirinyaga, Nyeri, Meru and Muranga) and (*e*) the dry eastern and coastal areas (Kilifi, Kitui, Machakos, Taita/Taveta and Tana River). The analysis used reverse stepwise regression to select the variables that were most closely related to the infant mortality levels. A similar regression was carried out for 1969 infant mortality rates using as many of the same variables as possible. These included population density, population per acre of high potential land, female literacy, percentage urban, hospital and dispensary beds per thousand population per unit area and the ecological zones. The regression on the change in the infant mortality rate used the change in a number of the variables available for both 1969 and 1979 as well as the agricultural zones.

The regression analysis of adult mortality in 1965, e_{20}, included all of the variables used in the regression on infant mortality for 1969.

Table 46 shows only those variables that were statistically significant. The insignificant variables are discussed in the text.

TABLE 46. REGRESSION ANALYSIS OF DISTRICT INFANT MORTALITY RATES (IMRs) FOR 1969 AND 1979 AND OF THE CHANGE IN INFANT MORTALITY, 1969-1979

	Dependent variable			
Independent variables	*IMR 1969*	*IMR 1979*	*IMR 1979–IMR 1969*	*Life expectancy at age 20 1965*
Intercept	124.7	114.7	-7.1	44.12
Percentage of females educated, ages 25-29	-0.99	-1.12	-0.3	0.096
Population density	-0.16	-0.27	NS	NS
High-potential agricultural land	-8.04*	-9.88	NS	0.66
Kilometres of road	. .	0.38	. .	. .
Percentage urban	NS	NS	NS	-0.05*
Nyanza and Western provinces	74.4	59.9	-10.6	-3.56
Coast province and Kitui and Machakos districts	23.6		NS	NS
Kericho, Nandi, Trans Nzoia and Uasin Gishu districts	NS	NS	NS	1.60*
R^2	0.70	0.80	0.26	0.60

NOTE: All regressions excluded Nairobi, Mombasa and Sambura. With respect to statistical significance, "NS" indicates not significant at the 0.15 level; an "*" indicates a significance level (p) between 0.10 and 0.15; for all others, $p < 0.10$.

Key to variables used in table 46:

Percentage of females educated: Percentage of women aged 25-29 who have ever been to school.

Population density: The number of persons per km² of total area.

High-potential agricultural land: Per capita high-potential agricultural land in 1979 with annual rainfall of 857.5 mm or more (980 mm in Coast province).

Kilometres of road: The number of kilometres of all types of road per 1,000 km² of total area.

Percentage urban: Percentage of population living in market centres, administrative centres, and towns with a population of 2,000 or more.

Micro-analysis of mortality differentials

The 1977 National Demographic Survey I (NDS1) provided the sampling frame for the Integrated Rural Survey III (IRS3), which covered 10 per cent of the NDS1 sample.

Khata has used this data set to examine differentials in mortality using an index of child mortality suggested by Trussell and Preston (1982). It compares each woman's proportion deceased among her children with a standard proportion deceased for women of her age. In this case the standard proportion was the proportion reported by women in the age group in the survey. In these regressions each observation was weighted by the woman's expected number of child deaths. Khata also ran the regressions separately for each of five ecological zones.

Several researchers have used the Kenya Fertility Survey (KFS) to analyse differentials in child mortality. The most complete analysis was carried out by Mwaniki. The results are given in table 47. His analysis is similar to Khata's except that he based the ratio of actual to ex-

TABLE 47. REGRESSION ANALYSIS OF THE RATIO OF DECEASED CHILDREN TO EXPECTED NUMBER DECEASED, KENYA FERTILITY SURVEY, 1977-1978

Variable		*Coefficient*
Intercept		0.789
Mother's education[a]	None[b]	0.
	1-3	NS[c]
	4-6	-0.180
	7-9	-0.152
	10-11	-0.456
	12+	-0.328
Father's education[a]	None[b]	0.
	1-3	NS[c]
	4-6	-0.147
	7-9	-0.211
	10-11	-0.323
	12+	-0.449
Ethnic group[d]	Central Bantu[b]	0.
	Coastal Bantu	NS[c]
	Western Bantu	NS[c]
	Nilotic	0.570
	Nilo-Hamitic	-0.160
	Other	-0.218

TABLE 47 (*continued*)

Variable		Coefficient
Region[e]	Nairobi[b]	0.
	Central	NS[c]
	Coast	0.308
	Nyanza	0.228
	Rift Valley	NS[c]
	Western	0.425
	Eastern/North-Eastern	0.124
Urban/rural	Nairobi/Mombasa[b]	0.
	Other urban[f]	-0.128
	Rural	NS[c]
Mother's age[g]	15-19	0.208
	20-24	0.226
	25-29	0.091
	30-34,35-39,40-44	NS[c]
	45-49[b]	0.
Father's occupation[h]	Agriculture, home	0.574
	Agriculture, self	0.122
	Productive, paid	0.075
	All 7 other categories	NS[c]
Marital status[i]	Married once[b]	0.
	Widowed	0.243
	Divorced	0.250
	Separated	0.233
	Monogamous married 2+	0.434
	Polygamous 2 wives	0.148
	Polygamous more than 2 wives	0.112

[a] *Education:* Number of years of education as specified by the highest grade or form completed.
[b] Reference category.
[c] Not significant at the 0.15 level.
[d] Tribal identification grouped as follows:
Central Bantu: Kikuyu, Kamba, Meru, Embu, Tharaka and Mbere.
Coastal Bantu: Mijikenda, Taita, Pokomo, Riverine, Bajun, Swahili, Shirazi, Taveta, Boni and Sanye.
Western Bantu: Luhya, Kisii and Kuria.
Nilotic: Luo.
Nilo-Hamitic: Kipsigis, Nandi, Tungen, Cherangani, Tugen, Cherangan, Elgeyo, Pokot, Marakwet and Sabot.
Other: Turkana, Masai, Ogaden, Iteso, Degodia, Samburu, Gurreli, Boran, Other Somali, Ndorobo, Rendille, Oma, Gabbra, Ajuran, Njemps, Hawiyah, Gosha and others.
[e] Province of residence.
[f] Residence in a market centre, administrative centre, or other town with a population of 2,000 or more except for Nairobi and Mombasa, which are handled separately.
[g] Age at last birthday of woman reporting on the survival status of her children.
[h] Occupation of the woman's current husband, classified as follows:
Agriculture, home and self: agricultural, including both self-employed and hired.
Productive, paid: skilled and unskilled manual activities.
Other: non-workers, professional, clerical, sales, household workers, service workers and those with occupation not stated.
[i] Current marital status of the woman at the time of the survey.

pected deceased children on a model mortality schedule rather than on the reported proportions deceased in the survey. In addition, Mott (1982) has examined differentials in mortality using the complete maternity history information from the Kenya Fertility Survey. His study is particularly useful in analysing the effects of maternal age and birth order on infant mortality.

Kune (1980) analysed data on child mortality from the Machakos Project using probit regression. Because of the sampling design he selected, the regression coefficients should probably be interpreted as the effect of the dependent variable on the chance that a household had lost at least one child.

Socio-economic differentials (infants and children)

Data on socio-economic differentials in infant and child mortality are available from the 1969 and 1979 censuses, from the National Demographic Surveys and from the Kenya Fertility Survey. Although there are few data relating mortality differences to specific cultural practices and beliefs, indicators of socio-economic status and culture suggest that a large part of the mortality differentials and probably much of the decline in mortality are related to social change and/or economic development.

Education. There is general agreement among researchers in Africa that educational attainment of parents is inversely related to infant mortality (Caldwell, 1979, 1981; Cochrane, 1980; Farah and Preston, 1981). This inverse association has been attributed to many causes including (*a*) breaks with traditional child-raising practices, (*b*) decreased fatalism about illness and increased use of modern medical facilities, (*c*) better utilization of available foods and increased availability of higher-quality foods made possible by increased income and (*d*) more personal and intensive attention by the mother with increased amounts of family resources spent on the child.

Differences in child mortality by mother's education are apparent in almost every analysis of mortality differentials in Kenya. For example, in both the 1969 and 1979 censuses the more educated women in every age group reported a lower proportion deceased among their children. Despite the clear relationship between education and child mortality, it is not clear why education is related to child survival. In particular, it is not clear how much of the relationship is a direct effect of education and how much is due to factors correlated with education but not held constant in the comparisons. This problem is apparent in the inconsistencies that appear when we examine the results of different studies of the relationship between mother's education and child mortality.

In our regression analysis of district differentials (table 46), we found that in both 1969 and 1979 each additional percentage point for women aged 25-29 with some education was associated with a decrease in the infant mortality rate of about one point per 1,000. The analysis of the change in infant mortality rate between 1969 and 1979 suggests a smaller effect of education: each one-point increase in the percentage of women educated in the age group 25-29 was associated with a decline in infant mortality of only about 0.3 per 1,000.

Kibet has examined estimates of differences in child mortality indices, $q(2)$, in the 1979 census by district and education group. In most districts, $q(2)$ was less than half as high for the children of women with a secondary education as for the children of uneducated women (see table 48). For example, in South Nyanza district, which has the highest level of $q(2)$, the children of women with a secondary education have a $q(2)$ of only 43 per cent of that reported by uneducated women. In

TABLE 48. CHILD MORTALITY INDICES, $q(2)$, BY EDUCATION OF MOTHER, KENYA, 1979

	Education of mother			
Province/district	*All mothers*	*NE*	*PE*	*SE*
Kenya	0.125	0.163	0.104	0.061
Nairobi	0.093	0.138	0.101	0.053
Central	0.067	0.094	0.063	0.042
Kiambu	0.070	0.103	0.069	0.045
Murang'a	0.068	0.087	0.065	0.047
Nyeri	0.049	0.079	0.049	0.031
Kirinyaga	0.082	0.101	0.073	0.041
Nyandarua	0.064	0.093	0.060	0.039
Nyanza	0.174	0.204	0.158	0.085
Kisumu	0.199	0.240	0.175	0.094
Siaya	0.211	0.237	0.190	0.123
South Nyanza	0.216	0.246	0.199	0.107
Kisii	0.101	0.129	0.088	0.054
Western	0.152	0.173	0.142	0.086
Kakamega	0.143	0.161	0.133	0.078
Bungoma	0.140	0.162	0.138	0.087
Busia	0.198	0.215	0.180	0.118
Coast	0.177	0.200	0.126	0.075
Mombasa	0.120	0.138	0.119	0.078
Kilifi	0.212	0.223	0.135	0.066
Kwale	0.190	0.200	0.148	0.068
Lamu	0.200	0.225	0.108	0.037
Tana River	0.181	0.186	0.170	0.119
Taita Taveta	0.116	0.139	0.110	0.057
Rift Valley	0.108	0.125	0.094	0.058
Laikipia	0.077	0.087	0.071	0.054
Narok	0.095	0.097	0.088	0.039
Kajiado	0.075	0.076	0.073	0.055
Turkana	0.133	0.137	0.150	0.076
Samburu	0.077	0.075	0.100	0.064
Nakuru	0.097	0.119	0.091	0.051
Baringo	0.171	0.211	0.113	0.065
Kericho	0.091	0.101	0.085	0.046
Uasin Gishu	0.092	0.107	0.081	0.061
Nandi	0.110	0.122	0.105	0.069
Trans Nzoia	0.114	0.124	0.110	0.075
Elg. Marakwet	0.127	0.156	0.108	0.052
West Pokot	0.188	0.201	0.118	0.043
Eastern	0.103	0.128	0.096	0.051
Embu	0.083	0.107	0.074	0.046
Meru	0.075	0.099	0.056	0.035
Isiolo	0.127	0.134	0.101	0.053
Kitui	0.148	0.162	0.120	0.092
Machakos	0.098	0.136	0.092	0.053
Marsabit	0.130	0.135	0.107	0.018
North-Eastern	0.135	0.139	0.120	0.043
Garissa	0.131	0.139	0.119	0.045
Wajir	0.129	0.130	0.107	0.022
Mandera	0.146	0.151	0.119	0.064

Source: M. K. I. Kibet, "Differential mortality in Kenya", unpublished M.A. thesis, University of Nairobi, 1981.

NOTE: NE = No education
PE = Primary education
SE = Primary education and above

the lowest mortality district, Nyeri, the comparable figure is 39 per cent.* This suggests that the relationship between maternal education and infant and child mortality is not an artifact of environmental factors or differences among cultural groups. However, table 48 also demonstrates that education is not the only important determinant of $q(2)$ since the women with a secondary education living in South Nyanza district report a higher $q(2)$, 107, than the uneducated women in Nyeri district, 79.

Mwaniki's analysis of the Kenya Fertility Survey data (table 47) demonstrates that mother's and father's education have almost exactly the same impact on child mortality. His results also show that for both parents, one to three years of education is not sufficient to affect mortality significantly. This analysis is especially interesting since the effects of maternal and paternal education remain significant when controlling for such related variables as father's occupation, mother's work status, religion and ethnic group. The addition of these other variables has almost no effect on the estimated effects of education. This suggests that education measures something other than income, residence or ethnic group variations in mortality. Kune's (1980) regression analysis of the determinants of mortality under age five in the Machakos Project study area also shows a strong effect of maternal education.

Some evidence of the way in which maternal education affects child survival comes from Maina-Ahlberg's study of the treatment of measles and diarrhoea in the same area (1979). She found that education had little effect on the likelihood that a child with measles or acute diarrhoea would be treated using modern medicine. There were no differences in the use of modern medicine unless the mother had more than eight years of education. However, she did find that education decreases the traditional practice of withholding water and milk from children with measles. Her results are summarized in table 49.

TABLE 49. EVIDENCE FROM MACHAKOS ON THE EFFECT OF MATERNAL EDUCATION ON THE TREATMENT OF MEASLES, 1975

		Percentage of mothers treating measles	
Education of mother	*Number*	*With modern care only*	*By banning water or milk*
None	102	52	75
1-4	67	45	61
5-7	66	50	48
8+	7	72	29

Source: B. Maina-Ahlberg, "Beliefs and practices concerning treatment of measles and acute diarrhoea among the Akamba", *Tropical and Geographical Medicine,* vol. 31 (1979), pp. 139-148.

NOTE: These two practices are not mutually exclusive, since banning fluids was not classified as a traditional treatment.

Given the persistence of the relationship between education and child mortality within districts, it is surprising that mother's education was significant in only one of Khata's separate regressions for the five ecological zones: women with one to six years of education in the Mt. Kenya area had significantly lower child mortality than other women. The difference between his analysis and those of other researchers is that he was able to include some variables more closely related to the level of economic development. For example, instead of such variables as father's occupation he could enter the household's reported monthly income, and instead of the district's level of road construction he used a direct measure of government services to the household: visits by a government officer to the house. Khata did find

* Kibet's estimates of $q(2)$ are based on the reports of women aged 20-34. A similar relationship between education and child mortality within districts is reported by older women.

education to be important in the regression for the whole country. It may be that in the national regression, education captured some of the other socio-economic differences among the regions of the country.

Union status. One important cultural difference among groups in Kenya is the prevalence of polygamy. Studies in other parts of Africa have demonstrated differences in infant and child mortality by type of union although the reasons for such differentials are not always clear. Polygamy might be related statistically to income differences, is often less common in urban areas, and may be related to religious and other cultural differences. The data on child survival and union status for Kenya refer to the woman's current status and to the number of wives of the current husband of the child's mother. Since widowhood and remarriage are common, the mother's current union status may be different from her status at the time of her births and her current husband may not be the father of all of her children.

Mwaniki's analysis of the Kenya Fertility Survey data shows that among ever-married women the currently married women who have only been married once report the lowest level of child mortality (table 47). The highest level is reported by women who are monogamous but who have been married more than once. After controlling for religion, mother's current age and ethnic group, these women report a rate that is 43 per cent higher than that of monogamous women who have been married only once. Polygamous women report a child mortality rate that is only 10 to 15 per cent above that of once-married monogamous women. These results suggest that the impact of cultural patterns related to polygamy on child survival may not be as important as the social and economic disruption caused by the breakup of unions through separation, divorce and widowhood. This conclusion is supported by Kune's regression analysis of mortality under age five in the Machakos Project (1980). He found lower mortality for children whose mother was married and whose father was resident with the family.

Father's occupation. The Kenya Fertility Survey provides information about the occupation of the mother's current husband. The occupation group that has the highest mortality is the agricultural workers who work at home; their children suffer a mortality rate 57 per cent higher than that of professionals even after controlling for maternal differences. Children of self-employed agricultural workers and paid production workers both have mortality rates about 10 per cent higher than other children. Differences among all other occupation groups become insignificant, although this might be partially due to small sample sizes for some of the groups. Differences by father's occupation probably reflect income differentials although they are also related to differences in culture and in proximity to medical facilities and urban centers.

Table 50 presents a tabulation of infant mortality rate and mortality at ages 1-4 years by father's occupation from the Kenya Fertility Survey. With the exception of children of professional and clerical workers, there is very little difference in the infant and child mortality by father's occupation, although the children of service workers show slightly lower mortality at ages 1-4.

TABLE 50. INFANT AND CHILD MORTALITY BY FATHER'S OCCUPATION, KENYA FERTILITY SURVEY, 1977-1978

Occupation	*Infant mortality rate*	*Mortality, ages 1-4* $({}_4q_1)$
No work	100	69
Professional, clerical	59	41
Housework, services	93	58
Sales, skilled, unskilled	93	71
Farmer, agriculture	96	75

Source: Unpublished tabulations.

Mother's place of work. The Kenya Fertility Survey data allow analysis of infant and child mortality differentials by the mother's place of work since her first union. It would be reasonable to hypothesize that this variable would affect child survival through differences in income, child feeding practices and possibly through increased use of modern medical care. However, after controlling for such other factors as mother's education, area of residence and father's occupation, there are no significant differences in child mortality by mother's place of work. This finding may be the result of conflicting influences such as increased bottle feeding and increased use of medical facilities by working mothers. The complex interactions between mother's employment outside the home and child mortality have not yet been studied in Kenya.

Religious identification. Although the infant mortality rate calculated from the Kenya Fertility Survey maternity histories shows higher mortality for Moslems, after adjusting for the factors included in table 47, there is no difference between Moslems and Catholics. Protestants still show slightly lower mortality (about 4 per cent); however, they are not significantly different from Catholics.

Ethnic group and tribe. The tribal affiliations entered in the regression analysis of the Kenya Fertility Survey probably represent cultural differences which are not related to education and income variables. Although the tribal groups tend to be located in specific parts of the country, the regional variables absorb most of the geographic differentials.

The most striking difference among the tribes is the excessive infant and child mortality among the Nilotic tribes (table 47). This excess of 57 per cent above the mortality of the Central Bantu is added to the regional disadvantage of Nyanza province where the majority of the largest Nilotic tribe, the Luo, live. The regression suggests that the excess mortality along the coast is more closely related to geographic considerations than to tribal differences since the Coastal Bantu do not have rates significantly different from the Central and Western Bantu once the regional differences have been removed.

Nutritional status of children. Malnutrition is often proposed as an important link between child mortality and socio-economic status. The relationship between nutrition and mortality is explored more completely in the next section. However, it is possible to use regression analysis to test the statistical relationship between the prevalence of malnutrition in an area and the level of child mortality.

The third national nutrition survey provides estimates of the proportion of children suffering from malnutrition for most districts. Since nutritional stunting reflects the effects of long-term malnutrition, it is reasonable to expect that the prevalence of stunting should be related to the level of child mortality. When these estimates were included in the regression on the infant mortality rate for 1979, the proportion stunted proved to be insignificant even at the 0.50 level. This was true whether or not the regional variables were included. This is probably the most surprising result from the regression analysis. Since the causes of death among children in Kenya suggest that the interaction between nutrition and infection must be an important factor underlying the high mortality rates (see below), it is difficult to explain the lack of correlation between the estimates of the proportion stunted and the estimated mortality rate.

Mosley's analysis of the provincial differences in child mortality (1983) noted that differences in education and income explain most of the variation in $q(2)$ between provinces. We have tested a similar model using the district estimates of female education and the proportions stunted from the third national nutrition survey. The results of this simple multiple regression show that female education, as measured by the proportion of women aged 25-29, and the proportion stunted are both significant at the 5 per cent level. The two variables explain 50 per cent of the variance in the infant mortality rate among the 31 districts for which we have data. However, as mentioned above, the proportion stunted becomes insignificant when we add other variables to the regression. In particular, adding the proportion of out-patient cases due to malaria leads to the proportion stunted being insignificant ($t = 0.83$).* Therefore, we are not able to conclude that education and malnutrition explain most of the variation in infant and child mortality. These issues will be examined in more detail in the discussion of malnutrition as a cause of death.

Miscellaneous factors. Khata's analysis by ecological zone shows that availability of sewage disposal reduced child mortality significantly in the coastal and the dry middle zones. Recent visits to the household by government officers (e.g., agricultural extension workers or health workers) was related to lower mortality in the wet middle and western zones.

Concluding comments on socio-economic factors

In all of the studies of the social determinants of child mortality, education appears as a central variable. There are, however, some confusing results relating to the impact of education. For example, the regression on changes in infant mortality at the district level showed a much smaller impact of the change in education than would be expected from the regressions on the level of mortality. Second, in Khata's regressions on individual level data from the Kenya Fertility Survey, he found education to be very important in the national regression, but not significant in most of the regressions for individual zones. The question becomes how much of the apparent effect of education is a direct effect and how much is due to spurious correlations caused by a failure to measure the appropriate social or economic differences.

For the purpose of sorting out the effects of education on mortality it is useful to distinguish between four ways in which education might be related to mortality. The first might be called the "teaching effect": the direct effect of the subjects taught in the schools. This would include lessons on topics like nutrition and hygiene. The second effect might be termed the "teacher effect". Young children who spend a lot of time learning material taught to them by a teacher may be more open to learning from non-traditional opinion-makers. Because of this experience they may be more likely to take advice from doctors, nurses, agricultural extension workers and other persons engaged in development activities after they leave school.

The third and fourth factors are the ones that might make it difficult to sort out the direct and indirect effects. The third might be termed the "selection effect". Children from less traditional families or those living in areas where development is proceeding at a rapid pace are more apt to go to school, to go to better schools, to succeed in school and to continue in school longer. Therefore some of the correlation between school attainment and child mortality may be a spurious correlation caused by our inability to control properly for the characteristics of the woman's parents and for the characteristics of the community. The fourth factor is the "increased opportunity effect": those who succeed in school have increased opportunities to move into more modern occupations and to earn more money. For women, the increased opportunity might be an increased chance of marrying a man in a higher occupation group or with a higher income. If occupation and income are related to child mortality a failure to control properly for income differences could lead to the appearance of a direct effect of education on child mortality.

Consideration of the effects of education in this way highlights the fact that education is only part of the process of cultural change that accompanies development. Education advances cultural change through the subjects taught and through the introduction of a non-traditional opinion-maker; however, education is also more available and more successful in those areas where other kinds of cultural change are underway. Khata's regressions suggest that education is only one form of government effort which encourages cultural change and which therefore affects child mortality. If cultural change could be measured directly, it might be found that general modernization and the associated changes in attitude are the main factors underlying the long-term mortality decline in Kenya.

One implication of this is that government programmes that introduce any type of modernization or cultural change can have an indirect impact on child mortality. This includes agricultural extension programmes and general development programmes as well as adult and child education. This can be particularly important to those areas that suffer higher than average

* The change from $q(2)$ to the infant mortality rate does not affect these results since the two sets of mortality estimates show virtually the same relative differences in mortality among areas.

mortality rates. Increased government development programmes in those areas might have the indirect effect of reducing child mortality by inducing general development and cultural change.

The lack of significance of the indicators of nutritional status from the third national nutrition survey is surprising and calls for further examination. In a recent paper, Mosley (1983) has argued on the basis of the provincial data that education and nutrition explain all of the variance in mortality. We are not able to confirm this hypothesis using the district data. However, Mosley's main point in that paper may still be valid. He argues that much, if not all, of the geographic differentials in mortality in Kenya are a result of regional differences in the level of economic and social development. This is an important hypothesis which we will discuss in our conclusions about the implications of the findings for health planning.

Environmental factors (infants and children)

This group of factors includes some which are related to socio-economic differences (e.g. high potential agricultural land per capita and urban residence) while others are more closely related to epidemiological principles (e.g. population density and prevalence of malaria). The one thing that they have in common is that they are all characteristics of populations rather than individuals.

Urban/rural differentials. Mortality differentials between urban and rural areas are apparent in many developing countries. Urban areas generally contain the largest share of the country's well-educated, high-income population and the best medical facilities; however, they do not always have the lowest mortality rates. For example, the estimated infant mortality rate for Nairobi is lower than the estimate for the whole country but higher than the estimates for nearby Central Province (table 45). Similarly, the value for Mombasa district is close to the national average and below the values for the other coastal districts (Kilifi, Kwale and Lamu). In the analyses of district differentials in both 1969 and 1979 (which exclude Nairobi and Mombasa) the infant mortality rate for a district was inversely related to its proportion urban; however, this differential became insignificant after controlling for other factors (table 46).

Regression analysis of the Kenya Fertility Survey also shows that the urban areas of Nairobi and Mombasa are not substantially different from the rural areas after controlling for other characteristics of individuals (table 47). This conclusion is based on the regional variable for Nairobi/Mombasa. Other urban areas have mortality rates which are about 13 per cent below those in rural areas.

The analysis of urban/rural differentials is not definitive because of the difficulty of measuring urban mortality rates using single round survey data on child survival. When women move from rural to urban areas, they report on the survival of both the children they have borne since moving as well as those who were born and may have died in rural areas. This problem biases the urban mortality estimates towards the rural levels.*

This lack of an advantage in mortality in large urban areas is surprising given the high concentration of medical and other resources in these areas. However, there are many factors that might tend to raise mortality rates above rural areas. For example, most cities and towns include a low-income population of recent migrants who have abandoned some of the traditional child-feeding practices such as extended breast-feeding, and who have not yet learned to take advantage of modern medical facilities. Mutanda (1980) reports that many women in Nairobi begin bottle feeding and mixed feeding during the child's first month of life and that their children begin to suffer from diarrhoea caused by rotavirus at an earlier age than children in Mombasa and Kisumu. It appears that after a control is done for the educational differences between urban and rural residents, the advantages of the high density of medical and other services are counterbalanced by these disadvantages. There is a need for a careful study of infant and child mortality in the large cities, focusing on mortality differentials that might be related to differential feeding practices and income.

Population density. Mortality can be related to population density either directly through increased spread of disease or indirectly through the availability of health services, schools and other advantages which sometimes appear in heavily populated areas before they are extended to sparsely populated places.

The authors' analysis of differences in the infant mortality rate among districts showed that after controlling for differences in literacy, and the per capita availability of high agricultural potential land, increased population density was associated with decreased mortality.

Per capita availability of arable land. While population density is an important element in epidemiologic models of mortality, population per unit of high quality agricultural land is probably a measure of average income in rural areas. In Kenya there is a great deal of diversity in the agricultural potential of the land. For example, although Kiambu has a population density about 45 times as great as Taita Taveta, the two districts have virtually the same ratio of population to high quality land.

In the authors' regressions on the district estimates of the infant mortality rate, it was found that areas with high quality land tended to have lower levels of infant and child mortality (table 46). This suggests that mortality rates are responsive to income, especially to agricultural income.

Transportation infrastructure. Data on the number of kilometres of road in each district are available for 1979. After controlling for population density, the number of kilometres was positively associated with the level of the infant mortality rates. This result runs counter to the expectation that the building of roads is a sign of development.

* There is also a bias in child survival estimates for rural areas which send migrants to cities if the out-migrants have mortality risks substantially different from the non-migrants. However, since out-migrants are rarely numerically important when compared with the number of non-migrants, the bias in rural areas is probably negligible.

Prevalence of malaria. Several studies have demonstrated a relationship between the prevalence of malaria in a population and its mortality rates. This is especially true of infant and child mortality rates after the first few months of life during which the child is protected by passive immunity to malaria acquired from the mother (Payne and others, 1976). Since malaria is prevalent 12 months of the year in some areas of Kenya and not present at all in other areas, it is possible that some of the mortality differentials among districts could be caused by differences in the prevalence of malaria. The possible contribution of malaria to mortality differentials in Kenya will be discussed in detail in a later section; however, the results of the authors' regressions are intriguing on this point. The regressions suggest that either malaria is a very important determinant of mortality differentials or that the malaria variable used here is closely correlated with a variable measuring geographic differences due to other mechanisms. When the regressions are run without the variables representing the six agricultural zones, the malaria variable is highly significant. However, when the zonal variables are included (table 46), the malaria variable becomes insignificant.

There are two possible interpretations of this result. The first is that malaria is not a significant determinant of mortality among infants and children but that several areas with high malaria rates have high infant mortality for other reasons. A second interpretation is that the malaria variable is not a good measure of the importance of malaria. The variable used here is the proportion of out-patient visits at hospitals and dispensaries which are reported as cases of malaria. This variable is affected by the availability of health services in an area and by the local diagnostic practices. For example, in holo-endemic areas, malaria may be over-diagnosed in clinics or it may be under-represented in out-patient cases. Therefore the zone variables could be acting as better indicators of the prevalence of malaria than the malaria variable. In any case, the regression results are not an adequate basis for evaluating the importance of malaria in determining differentials in infant and child mortality.

Regional differences and ecological zones. The variable for ecological zones in table 46 shows that the excess mortality in Coast, Nyanza and Western provinces is not explained by any of the other variables tested in the regressions. The entry of the provincial variables into Mwaniki's regression of the Kenya Fertility Survey data on child mortality (table 47) is similar to including ecological zones since the provinces and ecological zones tend to be similar. They probably absorb some of the differences due to climate and agricultural potential as well as some differences in economic development and culture. The lowest regional estimates are those for Central and Rift Valley provinces and the highest for Western province.

The excess mortality among infants and children near the lake and along the coast may be related to both the prevalence of malaria and to the high level of mortality to diarrhoeal diseases. Regional variation in the causes of deaths is discussed below in the section on causes of death among children.

Health services. The only measure of general health service available for the analysis is the number of hospital and dispensary beds per capita. Even when this variable was adjusted for differences in the size of the district (by dividing by the square root of the area), it was not significant in the regressions for 1969 and 1979. The change in the availability of hospital beds was also not significantly related to changes in the infant mortality rate between 1969 and 1979.

Demographic factors (infants and children)

The demographic factors affecting mortality rates include sex, maternal age, birth order and the interval beween births. Demographers sometimes refer to these as "biological factors" as opposed to "social factors" while epidemiologists tend to think of them as "demographic". Sex differentials in populations sometimes indicate differences in child-care practices for boys and girls and therefore may have implications for nutritional status and health care delivery. The other demographic variables discussed here relate to very different kinds of policy implications which frequently involve family planning measures for birth spacing, delaying of first births or lowering the mean age at last birth.

Sex differentials. Sex differentials in mortality were discussed above in the section on mortality levels. The sex differences in infant and child mortality appear to be slightly smaller than what are generally assumed to be biologically determined differences between the sexes. Therefore there is no evidence that sex differentials in mortality in Kenya are noticeably affected by significant differences in child care or feeding by sex.

Maternal age and birth order. These two variables probably have independent effects on infant and child mortality; however, it is very difficult to sort them out because of the high correlation between them. In Kenya there are few women who have their first birth after age 25 and few women under that age who have had more than four births. Therefore it is advisable to discuss these factors simultaneously while keeping in mind that statistical relationships involving one of these variables might actually reflect a causal relationship involving the other.

In Mott's analysis of Kenya Fertility Survey maternity history data (1982), he ran a regression on infant survival of the children born 12 to 119 months (i.e. 1-10 years) before the survey to test the importance of area of residence, urban residence, birth order and maternal education and age at delivery. The results showed that births of order two to four have the lowest infant mortality rate. Children of birth order five to nine and first-born children suffer a rate about 16 per cent higher than for those of birth orders two to four. When maternal age is included in the same regression, it indicates that the children of older women have lower risks of infant death. A separate analysis of the same data carried out at the United Nation's Population Division (unpublished) shows that this result is due largely to the higher infant death rate suffered by children born to mothers under age 20. Consistent with this is Mwaniki's regression on the Kenya Fertility Survey data which included the age of the mother at the time of the survey (table 47). The resulting coefficients show high relative risk at low age at delivery.

The Machakos Project provides data on the number of still births and infant deaths following 2,246 pregnancies in the period 1975-1976. The results are summarized in tables 51 and 52. Because of the limited number of observations and possible errors in the classification of still births, the numbers of still births and infant deaths are combined. The figures by birth order show the expected pattern of high mortality among first births and the lowest mortality among births of orders two and three. The pattern by maternal age is not quite as clear, but it does show evidence of lowest mortality among the births to women in the prime childbearing years of 25-34. Cross-tabulation by maternal age and birth order (see table 53) shows very high mortality for second and third births to women under age 20 which results from a combination of early first births, short birth intervals and probably some behavioural characteristics which affect both birth intervals and mortality risks.

TABLE 51. INFANT MORTALITY AND STILL BIRTHS BY BIRTH ORDER, MACHAKOS PROJECT, 1975-1976

Birth order	*Number of pregnancies*	*Infant mortality rate*[a]	*Infant deaths, still births*[b]
1	453	57	88
2-3	653	47	70
4-6	584	56	79
7-10	451	44	82
11-17	105	30	67
TOTAL	2 246	50	78

Source: A. M. Voorhoeve, S. Muller and H. W'Oigo, "The outcome of pregnancy", *Tropical and Geographical Medicine*, vol. 31 (1979), pp. 607-627.

[a] Per 1,000 live births.

[b] Per 1,000 terminations of pregnancy.

TABLE 52. INFANT MORTALITY AND STILL BIRTHS BY MATERNAL AGE, MACHAKOS PROJECT, 1975-1976

Maternal age	*Number of pregnancies*	*Infant mortality rate*[a]	*Infant deaths, and still births*[b]
Under 20	264	60	83
20-24	722	56	83
25-29	501	41	58
30-34	315	42	63
35-39	264	64	117
40-44	114	45	79
45-49	66	16	76
TOTAL	2 246	50	78

Source: A. M. Voorhoeve, S. Muller and H. W'Oigo, "The outcome of pregnancy", *Tropical and Geographical Medicine*, vol. 31 (1979), pp. 607-627.

[a] Per 1,000 live births.

[b] Per 1,000 terminations of pregnancy.

Birth intervals. The length of the interval between births can be an important factor affecting the mortality risks of infants. Mothers whose births are spaced too closely may not recover their health before becoming pregnant and this can hinder the growth and development of the fetus.

Analysis of the Kenya Fertility Survey data shows that higher neonatal and post-neonatal mortality rates are found for children born after a birth interval of less than two years. The impact is especially strong among those born following an interval of less than one year. These children suffer an infant mortality rate of 250, twice that of children who follow an interval of 12-23 months. With an interval of 24-36 months, the infant mortality rate is only 68. These differences persist after adjusting for the effects of a number of other variables such as parent's occupation, mother's education, and religion. The excess risk continues past the first year of life; those following an interval of less than one year have a risk at one to four years that is about 30 per cent above the risk of those following an interval of 25-36 months.

Regression analysis of adult mortality

Table 46 shows the results of regression analysis of district level differences in life expectancy at age 20 (e_{20}). Adult mortality is related to the two main socio-economic indicators: the proportion of women aged 25-29 who are educated and the per capita availability of high potential agricultural land. Both variables show that those districts with a higher level of development and income have lower adult mortality (i.e., higher e_{20}).

The surprising result is that a higher proportion urban seems to be associated with higher adult mortality. Since the effect is small and only marginally significant, it would be a mistake to make too much of this result. (It

TABLE 53. STILL BIRTHS AND INFANT DEATHS PER 1,000 TERMINATIONS OF PREGNANCY, BY BIRTH ORDER AND MATERNAL AGE, MACHAKOS PROJECT, 1975-1976

Maternal age	*Birth order*				
	1	*2–3*	*4–6*	*7–10*	*11–17*
Under 20	76	111[a]			
20-24	101	72	93[a]		
25-29	(50)[b]	59	63	(0)[b]	
30-34	(0)[b]	(0)[b]	71	58	(167)[b]
35-39		(0)[b]	(83)[b]	110	(88)[b]
40 +			(91)[b]	87[a]	46[a]

Source: A. M. Voorhoeve, S. Muller and H. W'Oigo, "The outcome of pregnancy", *Tropical and Geographical Medicine*, vol. 31 (1979), pp. 607-627.

[a] Based on 50-99 pregnancies.

[b] ( ) based on fewer than 50 pregnancies.

should be noted that Nairobi and Mombasa were not included in this regression.)

The regional variables provide two interesting findings. First, although the districts around the lake have excessive adult mortality just as they have excessive child mortality, there is no evidence of excessive adult mortality along the coast. This might suggest that the excessive infant and child mortality along the coast is due more to the high rates of malnutrition in that area than to the high rates of malaria, since malnutrition would affect mostly children. One reason why malaria might not affect adult mortality along the coast could be the use of presumptive chemotherapy for fevers with chloroquine from health clinics or commercial outlets.

The second interesting finding about regional differences is the slight mortality advantage in Kericho, Nandi, Trans Nzoia and Uasin Gishu. Since this difference is small and only marginally significant, it may be due to problems with the estimates of adult mortality more than to real differences in mortality.

Conclusions

The statistical analysis of areal mortality estimates and individual reports of child survival provide evidence of the effect of socio-economic status on both child and adult mortality, but very little information about the environmental conditions and the specific modes of behaviour that affect mortality. It seems clear that general social and economic development is related to declining mortality and that educational, agricultural and other development programmes will often have desired effects on health. However, this statistical analysis provides little guidance for the development of programmes designed specifically for improving health.

The health budget in Kenya, as in all of Africa, is quite small compared with the budget for education. Therefore it is especially important for health programmes to be directed at those areas where they are most needed and most apt to have a significant impact. The study of areal differentials in mortality have identified geographic areas where mortality levels are above average, but the statistical analysis of these differentials provides few clues about efficient ways of dealing with these high rates.

There is a need for social science and epidemiologic research on the behavioural and environmental reasons for excessive mortality rates in certain areas and among certain social groups (for example, the children of uneducated women). The national nutrition studies provide some useful clues, but even these studies provide little useful evidence on the precise feeding practices and food preparation techniques that are related to malnutrition.

Kenya now has a number of excellent national surveys which provide an overview of differentials in mortality and nutritional status. What is needed is a series of small-scale surveys designed to identify behavioural practices that can be altered through carefully designed health programmes. This might include studies of child-feeding practices, in-home treatment of diarrhoeas and fevers, and the use of modern medicines acquired through commercial channels (e.g. chloroquine, cough medicines and antibiotics). These studies are most needed in those areas where the risks of mortality and malnutrition are highest.

D. Causes of death

Main causes of death among children

There are two sources of national data on causes of death among children. The first is the reports of hospitals and clinics about in-patient deaths. Fendall and Grounds (1965a; 1965b) reviewed the data for 1962 for children aged 0-5 and data have been published for the nation and for each province for the year 1978.

The second source is data on registered deaths from the Registrar General's office. In particular the authors have made extensive use of unpublished tabulations of deaths in 1977 by age, sex, cause, district and type of certification (medical and non-medical). Table 54 presents estimates of the percentages of deaths reported to the Registrar General for 24 districts. The coverage estimates are based on the age distributions from the 1979 census and the life tables underlying the mortality estimates given in table 45. These 24 districts include all of the districts with more than 20 per cent of the deaths reported as well as a few districts added for regional comparisons (for example, Kilifi and Kwale). The highest coverage rates for infant and child deaths are for Siaya (64 per cent), Kiambu (73 per cent) and Nyeri (61 per cent); however, only 7 per cent of the deaths reported in Siaya were medically certified, and therefore the attribution of cause of death is often not reliable. In

Table 54. Estimates of completeness of death registration for 24 districts in Kenya, 1977

District	Percentage aged 0-4	Completeness	
		Age 5+	All ages
Nairobi[a]	47	46	46
Kiambu	69	76	73
Kirinyaga	48	53	51
Muranya	47	49	48
Nyandarua	43	35	39
Nyeri	63	61	61
Kilifi	6	6	6
Kwale	10	17	13
Lamu	19	20	19
Mombasa[a]	54	79	68
Embu	41	46	44
Machakos	40	44	42
Meru	31	15	21
Kisumu	27	36	31
Siaya	72	56	64
S. Nyanza	9	12	10
Kajiado	28	25	27
Kericho	15	12	14
Laikipia	37	29	32
Nakuru	28	45	37
Nandi	24	32	29
Narok	24	10	16
Bungoma	23	27	25
Kakamega	28	35	32
Kenya	27	27	27

Source: Based on comparison of registered deaths with deaths implied by life tables presented in the annex to this chapter.

[a] The estimates for Nairobi and Mombasa are less accurate than those for other districts and should be used with caution.

general, the highest coverage rates and the highest proportion medically certified are for Central province and the surrounding districts.

Comparisons among the districts of the reported mortality rates due to various causes are complicated by the large variation in the coverage rates. In order to partially overcome this problem two approaches have been taken in the discussion that follows. The first is a comparison among districts of the percentage of registered deaths due to each cause. If the coverage rates for various causes are similar, then the percentage of deaths due to a given cause will reflect its relative importance in the district. This is the approach used by Fendall and Grounds.

The second approach is based on the assumption that the reporting rate for the cause in question is not less than the coverage rate for all deaths. We can then calculate a range of estimates for each cause. The lower value for the range is the reported rate for the cause, i.e. the number of reported deaths divided by the approximate population, while the higher is the reported rate for the cause divided by the coverage rate for all causes. The assumption underlying the higher estimates is the same as that used in the first approach. Although these values are not true minimum and maximum estimates, they do provide a reasonable range of estimates and the width of the range is related to the amount of uncertainty in the estimates. In general, the upper estimate is probably closer to the actual level.

In addition to the national level data, we have used estimates from a number of specialized studies of small areas including the Joint Project Machakos. These studies frequently provide mortality rates, case fatality rates and estimates of the proportion of all deaths which are due to a given disease. Although no area of Kenya is truly typical, these small area studies often provide some guidance in selecting reasonable values for the whole country.

The following sections discuss the major causes of death among children. For each major cause, an attempt is made to estimate the national mortality rate due to the cause as well as to discover geographic patterns in the importance of the disease. Child mortality due to tuberculosis and malaria will be discussed along with adult mortality in the next part of this section.

Respiratory infections. Respiratory infections are the main cause of death among infants and children in Kenya. At ages 0-4, 28 per cent of the registered deaths in 1977 were ascribed to this cause. Among the in-patient deaths due to respiratory infection, 90 per cent were ascribed to pneumonia, 4 per cent to acute respiratory infection and 4 per cent to bronchitis and asthma. Among medically certified registered deaths in 1977, 89 per cent of respiratory deaths were due to pneumonia. Approximately 30-35 per cent of all infant deaths were due to respiratory infections (29 per cent in the 1977 registered deaths, 35 per cent in the 1978 in-patient deaths, and 32 per cent in the Machakos study area).

Fendall and Grounds noted that deaths due to respiratory infections reported in hospitals in 1962 represented a larger proportion of all deaths at ages 0-4 years in the cooler, wetter areas of Central, Eastern and Rift Valley provinces than they did in Coast, Western and Nyanza provinces (1965a:79). Similarly, among deaths registered in 1977 (see table 55) respiratory deaths accounted for a higher proportion of the infant and child deaths in Central, Eastern and Rift Valley provinces (30-40 per cent) than along the coast and around the lake (about 20 per cent). However, there is no reason to believe that death rates due to respiratory infections are higher in Central, Eastern and Rift Valley provinces. The range of estimated rates in Central province, 3.7 to 6.6 per 1,000 (reported and adjusted rates), is not substantially different from the range for the other 16 non-urban districts shown in table 55 of 2.3 to 9.2. A comparison of Nairobi and Mombasa leads to a similar conclusion. The range of estimates for Nairobi is 3.1 to 6.6 (reported and adjusted for coverage) while for Mombasa the range is 3.0 to 5.6. These data suggest that respiratory infections are a serious cause of death in all parts of the country including the districts with the lowest mortality levels.

Respiratory deaths among children are frequently associated with malnutrition and/or with other infectious diseases. For example, a large proportion of the deaths following measles are due to respiratory complications. Repeated bouts with infectious diseases

TABLE 55. CHILD MORTALITY DUE TO RESPIRATORY INFECTIONS AND GASTRO-ENTERITIS (DIARRHOEA) BY DISTRICT, REGISTRAR GENERAL'S DATA, KENYA, 1977

	Deaths at age 0-4 per 1,000 population[a]		*Percentage of reported deaths at ages 0-4*	
Province/district	*Respiratory*	*Diarrhoea*	*Respiratory*	*Diarrhoea*
Nairobi	3-7	0.9-2.2	32	10
Central province				
Kiambu	5-7	1.1-1.7	46	10
Kirinyaga	4-9	2.0-4.3	27	17
Muranga	3-6	0.9-2.0	32	11
Nyandarua	4-9	1.0-1.9	54	12
Nyeri	2-4	0.5-0.9	30	6
Coast province				
Kilifi	1-19	0.2-3.7	32	10
Kwale	1-10	0.8-9.4	16	16
Lamu	2-10	2.2-13.0	18	25
Mombasa	3-6	1.9-3.6	18	11
Eastern province				
Embu	3-8	1.0-2.6	35	11
Machakos	3-7	0.9-2.3	28	9
Meru	3-9	0.7-2.4	38	10
Nyanza province				
Kisumu	3-12	1.4-5.5	20	10
Siaya	6-9	4.4-6.4	15	6
Rift Valley province				
Kajiado	2-5	1.1-2.7	28	14
Kericho	1-7	0.7-5.0	29	20
Laikipia	3-10	0.6-2.0	48	10
Nakuru	2-9	1.0-4.0	35	15
Nandi	3-12	1.5-6.4	40	21
Narok	4-23	0.3-2.2	60	5
Western province				
Bungoma	2-11	1.3-6.9	28	19
Kakamega	2-7	1.3-4.7	17	11

Source: Unpublished tabulations from the Office of the Registrar General.

[a] The lower rate is the reported value while the higher rates are equal to the reported rate divided by the estimated coverage of child deaths.

increase the probability of a child's becoming malnourished, and malnutrition in turn can make the child more susceptible to serious infections. Therefore, the high mortality rates due to respiratory infections among children should be considered as part of a complex of infectious diseases and malnutrition.

Gastro-enteritis and dysentery. The second most frequently reported cause of death among infants and children is diarrhoea. Fendall and Grounds (1965b:114) report that in 1962 gastro-enteritis and dysentery were responsible for about 16 per cent of the deaths among children aged 0-5 reported by hospitals. The comparable figure for 1978 for ages 0-4 was 10 per cent. Among the registered deaths in 1977 about 11 per cent of the infant deaths were assigned to this cause, while the comparable figure for the Machakos study area for the period 1974-1977 was about 16.5 per cent.

In the 24 districts listed in table 55 (including Nairobi and Mombasa) the estimated range of estimates is 1.1-3.9 (reported and adjusted for coverage). Fendall and Grounds (1965b:114) noted that diarrhoea was a more important cause of death than respiratory infections in the Coast, Western and Nyanza provinces. They apparently ascribed this to the increased rates of mortality due to respiratory infections at the higher altitudes. However, as we have seen there is no evidence that mortality due to respiratory causes is actually higher in Central, Eastern and Rift Valley provinces today.

The evidence from the 1977 registered deaths summarized in table 55 does suggest that diarrhoeas are a more important cause of death along the coast and around the lake than elsewhere. For example, Mombasa has a reported death rate due to diarrhoeas twice as high as Nairobi's (1.9 as compared with 0.9 per 1,000). Although the coverage rates for the Registrar General's data for Kwale and Lamu are very low (9 per cent and 17 per cent for ages 0-4), the reported death rates to diarrhoeas in these districts (0.8 and 2.2 per 1,000) are similar to the reported rate for Central province (1.1 per 1,000) where 53 per cent of the infant and child deaths are reported. The reported death rates due to diarrhoea in Kisumu and Siaya are also greater than those reported in Central province. The estimated range for diarrhoeal mortality in Central province (1.1-2.0 per 1,000) is much lower than the estimated range for six districts along the coast and around the lake. Although exact comparisons cannot be made, it does appear that diarrhoeal mortality is much higher along the coast and around the lake than in other parts of the country.

Data from the Machakos study area suggest that the age incidence of diarrhoea is related to weaning practices. The incidence of diarrhoea reaches a peak at ages 6-11 months (Leeuwenburg, 1978) even though most children have lost maternal antibodies by age 3-5 months. Antibodies against rotavirus in sera from children in Machakos show that only 37 per cent of children aged 3-5 months had antibodies (Metselaar and others, 1978:533). However, diarrhoeas do not become common in Machakos until children are introduced to solid foods beginning about age 7 months. Children tend to start receiving some cow's milk at about 1-4 months of age and from 4-5 months onwards they begin to get a thin porridge. Both the milk and the porridge are boiled once for the whole day. Hard-maize flour porridge (*ugali*) sometimes mixed with tomatoes is introduced at about 7-11 months of age. Leeuwenburg and his colleagues therefore ascribe the peak in diarrhoea at 6-11 months to weanling diarrhoea as described by Gordon, Chitkara and Wyon (1963).

An analysis of contamination in weaning foods in the Machakos Project area (van Steenbergen and others, 1983) demonstrated that 44 per cent of samples showed severe contamination with *Enterobacteriaceae* (including *E. coli, Salmonella* and *Shigella*) and 12 per cent were severely contaminated with *Staph. aureus.* The degree of contamination seems to be related to the length of storage time after preparation. The same study found that only a low percentage of samples of drinking water from rivers and open wells showed any sign of contamination. Therefore the contamination of weaning foods is probably the cause of much of the diarrhoea found in Machakos.

Mutanda provides a different explanation for the peak incidence of diarrhoea seen at Kenyatta National Hospital in Nairobi. His study shows that diarrhoea admissions are most frequent for the age group 3-5 months which he attributes to the waning of maternal antibodies against rotavirus. Among children under 2 weeks of age delivered in the Hospital, 73 per cent had antibodies to rotavirus. For patients admitted at 2-5 months of age, only 11 per cent showed antibodies (Mutanda, 1980). Mutanda states that mothers in Nairobi begin bottle-feeding and mixed feeding during the first month of life and the Kenya Fertility Survey shows that on the average children are weaned several months earlier in Nairobi than in the rest of the country (Kenya, Central Bureau of Statistics, 1980:156). Mutanda concludes that the peak age of serious diarrhoea in Nairobi is associated with the loss of the maternal antibodies rather than with the introduction of bottle-feeding. However, it is likely that the role of bottle-feeding or mixed feeding as a cause of severe diarrhoea is merely delayed by the maternal antibodies.

Mutanda's data also provide some useful insights into regional differences in infant diarrhoeas. He examined patients admitted to Kenyatta National Hospital and the pediatric wards of the Mombasa and Kisumu provincial hospitals with diarrhoea as their main complaint. There were two important differences among the three areas. First, while in Nairobi there was a peak in the incidence at 3 to 5 months, in Kisumu there was no such peak; the distribution was quite flat. In Mombasa, there was a heavy concentration of cases over age 12 months (see table 56). This suggests that the role of maternal antibodies in the determination of the peak age of incidence is unique to Nairobi.

The second difference among the areas is in the type of infections found among the infants. In Nairobi about 40-45 per cent of the children in each age group of infants were infected by rotavirus, while in Kisumu the percentages were closer to 25 per cent. In Mombasa, among children aged 3-8 months the incidence of rotavirus was about 25 per cent but at 0-2 months the percentage was 13 per cent and at ages 9-11 months it was only 6 per cent (table 56). Therefore rotavirus may be responsible for a larger percentage of severe diar-

TABLE 56. COMPARISON OF HOSPITALIZED PATIENTS WITH DIARRHOEA, NAIROBI, KISUMU AND MOMBASA

District	Age in months					
	0-2	3-5	6-8	9-11	12+	Total
	Percentage of cases					
Nairobi (160 cases)	8	36	25	9	22	100
Kisumu (104 cases)	13	22	26	16	23	100
Mombasa (112 cases)	13	14	13	15	44	100
	Percentage with rotavirus					
Nairobi	42	47	40	47	29	41
Kisumu	23	26	26	29	8	22
Mombasa	13	25	27	6	12	15
	Percentage with Shigella					
Nairobi	0	10	5	13	20	11
Kisumu	8	0	4	12	8	7
Mombasa	7	0	18	24	20	25
	Percentage with E. coli					
Nairobi	33	19	15	27	11	18
Kisumu	8	4	11	12	4	8
Mombasa	27	0	0	12	0	5

Source: L. N. Mutanda, "Epidemiology of acute gastroenteritis in early childhood in Kenya: III, Distribution of the aetiological agents", *East African Medical Journal*, vol. 57 (1980), pp. 317-326.

rhoea cases in Nairobi than in the other areas, and its age pattern of incidence may be different in Mombasa than in the other two areas. In Mombasa and Kisumu *Shigella* infections also differed. In Mombasa and Kisumu *Shigella* was rarely isolated before 6 months of age, whereas in Nairobi *Shigella* infections started to appear among those aged 3-5 months. Finally *E. coli* affected 20 per cent of the infants (those under 12 months) in Nairobi but only 9 per cent in Kisumu and Mombasa. In Mombasa, four of the six cases of *E. coli* were found among bottle-fed neonates. *Salmonella*, which appears to be an important element in diarrhoea in the Gambia, was rarely found in these three towns.

The differences among the age patterns of incidence and among the frequency of the various disease agents suggest that there are very different patterns of diarrhoea infections in Kenya. The importance of child-feeding practices is evident in the Machakos data and in Mutanda's results. In addition, Fendall and Grounds (1965b:114) state that of children who died in hospitals from diarrhoeas in 1962, 50 per cent were also diagnosed as suffering from malnutrition. Because of the importance of diarrhoea as a cause of death further research is needed on the details of child-feeding practices and their relationship to malnutrition and mortality. Such research will be especially important for the design of health programmes for rural areas along the coast and around the lake because of the high rates of diarrhoeal mortality in those areas.

Measles. Historically, measles was a severe public health problem in Kenya and may still be associated with 20 per cent of all deaths at 6 months to 4 years of age. Although numerous studies have been carried out on various aspects of measles morbidity and mortality in Kenya, it is still difficult to estimate the precise importance of this disease. Analysis of the available data is hindered by two factors: (*a*) the interaction between measles and other causes of death and (*b*) the increasing use of measles vaccination which complicates comparisons of data for different areas and different time periods.

A large proportion of those whose death is associated with measles die after the acute phase of the disease from complications such as respiratory infections and gastro-enteritis (Hendrickse, 1975). Hayden (1972) found that, of 469 deaths associated with measles in Nairobi in 1970, measles was listed as the only cause of death for only 7 per cent. Seventy-two per cent were recorded as primarily due to respiratory causes, 6 per cent were due to gastro-enteritis and another 9 per cent were primarily caused by respiratory and diarrhoeal causes combined. Oomen (1976) reports that among inpatients at the Machakos Provincial Hospital in the period 1967-1974 there were complications in 59 per cent of the measles cases but almost all (97 per cent) were recorded as measles deaths. In Tanga District Hospital in Tanzania (adjoining Kwale District), 30 per cent of the measles cases admitted in 1974-1975 had pneumonia and another 6.8 per cent developed pneumonia while in the hospital. The case fatality rate for those admitted with pneumonia was 11.7 per 1,000 as compared with only 6.4 for those admitted without complications (Gupta and Singh, 1975). There is also clear evidence of a relationship between malnutrition and measles fatality from the Machakos Project (Muller and others, 1977), from Nairobi (Hayden, 1972), and from Northern Tanzania (Gupta and Singh, 1975; Kimati and Lyaruu, 1976). Because of these interactions, it is virtually impossible to estimate the true impact of measles on mortality rates. Eliminating measles may prevent some deaths due to other causes (especially respiratory diseases); however, the malnourished children who are most apt to die from measles are also at increased risk of death from other causes.

The second complication in the study of measles mortality is that there has been a steady increase in the use of measles vaccine in Kenya. That causes several problems for analysis. First, information on mortality due to measles in some areas with reliable data (e.g. Machakos and Nairobi) is difficult to extrapolate to other areas which may have a very different percentage of the population protected by immunization. Second, case fatality rates are available for some areas, but they cannot be used to estimate mortality rates without estimating the average annual number of cases, which depends on the proportion immunized. In addition, estimates of mortality due to measles based on data collected 5 to 10 years ago may no longer reflect the importance of the disease because of increasing proportions vaccinated. Increased vaccination not only decreases the number of cases but can also increase the average age at acquiring measles by decreasing the frequency of epidemics. Since measles fatality is highest among the youngest children, increasing the average age at incidence can also decrease the fatality rate.

Finally, data on the number of vaccinations performed does not always reflect the number of childen protected by immunization. If children are immunized at too young an age (6-9 months), the vaccine is not effective because of the presence of the temporary immunity acquired from the mother. Also measles vaccine must be kept cold until it is used. It is likely that vaccine failure was responsible for the measles epidemic in the study area of the Joint Project Machakos despite an extensive vaccine campaign (World Health Organization, 1982).

National estimates of measles mortality are available from the reports of in-patient deaths in hospitals and clinics and from deaths reported to the Registrar General's Office. In 1978, 583 measles deaths of children under 5 years of age were reported by hospitals and clinics. This amounts to a measles mortality rate at 0-4 years of 0.3 per 1,000. In 1977, the Registrar General reported 2,539 childrens' deaths due to measles, which gives a mortality rate of 0.9 per 1,000. These mortality estimates most likely underestimate the true rates because of underreporting of cases.

The Joint Project Machakos provides extensive information on measles mortality. The mortality rate at ages 0-4 due to measles in the study area was 2.7 per 1,000 during the period April 1974 to March 1977 (Muller and others, 1977). However, during the next 48 months (April 1977 to April 1981) there were many measles cases but apparently no additional measles deaths (World Health Organization, 1982). It is possible that some improperly stored vaccine used in the measles vaccination campaign may have been too weak to prevent cases, but effective enough to reduce the severity of cases and therefore to reduce the number of deaths (Muller and others, 1977). Therefore, for the entire period (1974-1981) the mortality rate for measles at ages 0-4 was only 1.2.

The Registrar General's data for the whole of Machakos district for 1977 indicate a mortality rate of 1.8. If measles deaths were underreported as frequently as all deaths at ages 0-4 in the district, the estimate increases to 4.6.

Examination of the reports to the Registrar General of measles deaths in Kiambu, Muranga and Nyeri districts, where the completeness of reporting is highest, shows measles mortality rates of 0-4 of 0.8, 1.2, and 1.3 for 1977. If it is assumed that the underreporting of measles deaths is the same as the underreporting of all deaths at ages 0-4, the estimates increase to 1.5, 2.7 and 2.2. Although these three districts are more densely populated than most and therefore might have a lower average age at incidence of measles, they also have a higher proportion protected by vaccination and lower levels of malnutrition than other parts of the country.

Data from Nairobi and Mombasa are also apt to be more accurate than those for the rest of the country although they are also complicated by higher vaccination coverage, lower levels of malnutrition and relatively easy access to medical care. However, the 1977 Registrar General's data for the two cities indicate mortality rates of 0.6 and 0.9, almost as high as the national estimate of 0.9 from the same source. Earlier data from these cities lead to much higher estimates. O'Donnovan reports 507 child measles deaths in Kenyatta Hospital for 1968-1970. If these were the only measles deaths in the city, the mortality rate would have been 2.2. In 1972-1973, the Municipal Council clinics in Mombasa reported 127 measles deaths of children aged 0-6, which leads to an estimated mortality rate for ages 0-4 from measles of about 2.7. These are all minimum estimates for these areas.

An estimate can be made of the proportion of the eligible population which is protected by measles vaccination in each province by using the reported number of vaccinations performed during the period September 1979 to May 1980. By assuming that at any given time 21 per cent of the population in the age group 0-4 is aged 6 months to 18 months, that no child has received more than one vaccination, and that the vaccination rate has been constant during the previous few years, an estimate can be made of the percentage that has received a vaccination. These assumptions lead to estimated provincial coverage rates of 58 per cent for Central, 31 per cent for Coast, 63 per cent for Eastern, 21 per cent for North Eastern, 38 per cent for Rift Valley and 24 per cent for Western provinces. The national estimate is 41 per cent. The estimate for Central province is reasonably consistent with the results of two vaccination coverage surveys carried out in two districts in the province, Nyeri and Kirinyaga. The estimated coverage rates for measles vaccine was 46 per cent for Nyeri and 56 per cent for Kirinyaga (World Health Organization Regional Office for Africa, 1982). The difference between these estimates and the provincial estimates probably arise from the assumptions used to estimate the latter and to differences among the districts in the province.

These estimates may overstate the proportion actually protected. If the child still has maternal antibodies or has already had measles, or if the vaccine was not stored properly the vaccine provides no protection. If it is assumed that 41 per cent of children nation-wide will be protected against measles through vaccination and a case fatality rate is assumed of 6.5 per cent, as found in the Joint Project Machakos for the period 1974-1976, a mortality rate due to measles would be about 8 per 1,000 for the age group 0-4. Using the 95 per cent confidence interval for the case fatality rate from Machakos, a national estimate of mortality is found ranging from 4.3

to 11.9. If instead the reporting of out-patient cases of measles is relied on for the period September 1979 to May 1980, an estimated national mortality rate is derived of 2.5 to 6.9 per 1,000.

If Hayden's figure of 21 per cent of deaths under age 7 associated with measles in Nairobi for 1970 is applied nationally, this would give an estimate for 1970 of approximately 7 or 8 deaths per 1,000 aged 0-5 associated with measles. In the Joint Project Machakos, 22 per cent of the deaths at ages 0-4 were attributed to measles which leads to a national estimate of 6.8 per 1,000. Considering all of these estimates, it seems likely that the national mortality rate due to measles at ages 0-4 in 1980 was in the range of 4-9 per 1,000.

Pertussis. Fendall and Grounds reported that in 1962 whooping cough was responsible for 4.8 per cent of the in-patient deaths of children 0-5 years of age. In 1978 the comparable figure was only 1.9 per cent. Although these figures must be used cautiously, it is certainly likely that extensive campaigns to immunize children with DPT injections have reduced mortality due to whooping cough. Between September 1979 and May 1980, over 700,000 DPT shots were administered outside Nairobi. This amounts to 56 first shots and 93 second or third shots for every 100 infants. Vaccination coverage surveys in Nyeri and Kirinyaga in late 1980 show that about 71 per cent had received three DPT shots (World Health Organization Regional Office for Africa, 1982).

In the period September 1979 to May 1980, 41,694 out-patient cases of whooping cough were reported through the health information system. Using the case fatality rate from the Joint Machakos Project (1.2 per cent) the authors estimate that the mortality rate at ages 0-4 was about 0.3 per 1,000. Since vaccination coverage appears to be less than 75 per cent nationally, it is possible that the true rate may be slightly more than this.

Tetanus. Tetanus affects all age groups but is never a major cause of death except among neonates. In some populations in developing countries, neonatal tetanus (tetanus of the umbilical stump) kills as many as 80 per 1,000 live births and is the major cause of death among infants. In other similar populations, tetanus is infrequent.

Tetanus kills infants between the ages of 5 and 15 days and is characterized by painful muscular contractions and rigidity. Because of the dramatic symptoms, the rapidity of the disease, the age at which it strikes and the ineffectiveness of modern medicine (case fatality rarely drops below 45 per cent even with the most sophisticated care), many populations consider neonatal tetanus to have supernatural causes. Therefore, neonatal tetanus cases may not be seen in modern medical clinics and hospitals. Another source of understatement of tetanus mortality is the fact that it is very rare among deliveries in hospitals and dispensariesbecause of the use of sterile implements for cutting the cord.

It was noted previously that Coast and Western provinces had very high reported neonatal mortality rates in the Kenya Fertility Survey maternity histories. Although maternity histories frequently are unreliable at this level of detail, this finding does coincide with the fact that the districts with the highest proportion of reported infant deaths attributed to neonatal tetanus are Kilifi and Kwale districts in Coast province and Kakamega in Western province. In Kilifi, the 59 reported deaths due to neonatal tetanus in 1977 amounted to a rate of only about 2.7 per 1,000 live births; however, they accounted for 33 per cent of the reported tetanus deaths of infants in the whole country. If neonatal tetanus deaths are reported as frequently as all infant deaths, the mortality rate due to neonatal tetanus in Kilifi would be about 49 per 1,000 live births. Although neither of these extremes is apt to be an accurate estimate, it is quite likely that neonatal tetanus is a major cause of death among infants in these districts.

The potential importance of neonatal tetanus as a cause of death is indicated by the fact that if tetanus kills only 3 per 1,000 live births, it would be the ninth most common cause of death in Kenya.

Because of the unreliability of hospital and dispensary reports for tetanus deaths, it is important to investigate the significance of tetanus deaths using survey techniques in Coast and Western provinces. It is possible that neonatal tetanus may be an important factor in the high infant mortality rates in those areas.

Malnutrition and mortality. Malnutrition is a major factor underlying the high infant and child mortality in Kenya. Although it is not always evident in data on cause of death, severe malnutrition in children is frequently related to increased severity of infectious diseases and to increased case fatality rates for such diseases as measles, pneumonia and diarrhoea. Although the causal links between malnutrition and infections generally run in both directions, it is clear that an elevated prevalence of malnutrition is frequently associated with increased mortality rates.

Kenya is fortunate in having had three national nutrition surveys and smaller surveys in a number of districts. The 1977 national survey was incorporated into the Second Integrated Rural Survey (IRS II) administered by the Central Bureau of Statistics. It covered the rural areas of all the districts of Central, Western and Nyanza provinces, all of Coast province except Lamu, all of Eastern province except Isiolo and Marsabit, and Rift Valley except Turkana, Samburu, Laikipia and Kajiado districts. No data were collected in North-Eastern province. The excluded districts are generally sparsely populated areas in the northern part of the country and contain only a small proportion of the total population. Anthropometric measurements and information on feeding practices were collected for 1,400 children aged 12-48 months.

The second national nutrition survey was carried out in October 1977 and January 1978 as part of the Fourth Integrated Rural Survey (IRS IV). It collected similar data on 4,000 children aged 6-60 months in urban and rural areas. The second survey included all of the districts included in the first survey plus Samburu and Laikipia districts in Rift Valley province. Data were presented for the rural areas of each province (except North-Eastern) plus Nairobi, urban areas of Coast province (largely Mombasa) and all other urban areas combined.

The third national nutrition survey was carried out as part of the new national programme of integrated surveys with a sample based on the 1979 census. The rural segment was carried out as part of the Household Budget Survey between July and September 1982. The urban segment was carried out between February and April 1983. Only the results of the rural segment were available for review. The major advantage of the third national nutrition survey was that the sample size was about four times as large as the previous surveys (5,323 children aged 3-60 months in rural areas), which made possible analysis at the district level.

The list of small nutrition surveys includes several studies in Machakos district, including one done as part of the Joint Project Machakos, three surveys in different parts of Kisumu district, and surveys in Nyeri, Kirinyaga, Muranga and Meru districts. In addition to anthropometric data from the nutrition surveys, malnutrition case rates are available for 1979 and for the second quarter of 1980 from the health information system of the Ministry of Health.

Table 57 summarizes the nutritional status of children in the rural areas of six provinces and in several urban areas from the second national nutrition survey. These figures show that malnutrition is most prevalent in Coast province and is almost as serious in Nyanza and Eastern provinces. The results from the third national survey are quite similar. The highest levels of malnutrition are similar to those found in Tabora and Kiserawe districts of Tanzania in the mid-to-late 1960s and to estimates for Eastern Rwanda.

TABLE 57. COMPARISON OF MORTALITY BY AGE FIVE AND NUTRITIONAL STATUS INDICATORS, URBAN AND RURAL AREAS OF PROVINCES, SECOND NATIONAL NUTRITION SURVEY, KENYA, 1978-1979

Areas	*Mortality by age 5, q(5)*	*Percentage below 5th percentile of*		*Percentage normal*[a]
		Height/age	*Weight/height*	
Coast rural	221	54	14	47
Nyanza rural	205	51	9	56
Western rural	186	46	5	63
Coast urban	160	34	13	65
Other urban	133	38	10	68
Rift Valley rural	132	45	11	61
Eastern rural	123	47	11	58
Nairobi	100	28	7	74
Central rural	80	44	6	65
Correlation with $q(5)$:				
Total		.59	.39	−.72
Excluding Nairobi		.49	.31	−.66

[a] "Normal" means not stunted and not wasted.

Three measures of malnutrition are compared with estimates of the proportion dying by age 5, $q(5)$, in table 57. The first measure of malnutrition is the percentage of children who are below the fifth percentile of the standard distribution of height for age, which is a measure of stunting or long-term malnutrition. Unlike weight, which can change quite rapidly in response to improper nutrition, height changes slowly and therefore does not reflect the effects of short periods of malnutrition. The correlation between the percentage below the fifth percentile of height for age and the estimated proportion dying by age 5 is 0.59, which suggests that areas with more malnutrition also have higher child mortality rates. The correlation between $q(5)$ and the percentage below the fifth percentile on weight for height, a measure of wasting or recent malnutrition, is much smaller, only 0.39. This is to be expected since this measure of malnutrition is more heavily affected by short-term, seasonal fluctuations in nutrition which might not have as much effect on the long-term level of mortality. The highest correlation between mortality and malnutrition in table 57 is the proportion "normal" (i.e. not stunted and not wasted).

As noted above in the discussion of the regression analysis, the district estimates from the third national nutrition survey of the proportion stunted are correlated with the infant mortality rates at a level similar to that found at the provincial level. However, when included in a full regression analysis, the district estimates of the proportion stunted are no longer significantly related to mortality. It is unfortunate that the report of the third national nutrition survey did not include estimates of the proportion "normal" for districts.

The correspondence between the annualized rate of out-patient cases of malnutrition for 1979 and the second quarter of 1980 and the results of the national nutrition surveys is very poor. The highest rate of malnutrition cases is for Western province, which displays relatively low levels of malnutrition in table 57 while Eastern province shows few cases but high proportions malnourished. It is clear that the data on out-patient cases reflect the population coverage of health services and the completeness of reporting of the institutions in the various provinces rather than the prevalence of malnutrition.

An examination of the patterns of malnutrition by age from the second survey shows that the rural areas of Coast province are the only areas where the children aged 6-11 months have lower percentile heights for age than do children aged 12-23, 24-47 or 48-60 months (Kenya, Central Bureau of Statistics, 1977:27). This early appearance of nutritional stunting in Coast province is probably related to several characteristics of child-feeding practices in that area. Coast and Nyanza provinces have the longest median length of breast-feeding: 14.6 and 15.2 months as compared with 14 months for the rural areas of other provinces. In the rural areas of Coast and Nyanza, 18 per cent and 14 per cent of the children are breast-fed for more than 24 months as opposed to 7, 14, 5 and 7 per cent in the rural areas of Central, Eastern, Rift Valley and Western provinces.

Since breast-feeding cannot provide adequate calories for a healthy child past 6 months of age, prolonged breast-feeding must be accompanied by appropriate supplementary foods. In Coast province, 48 per cent of women reported that they did not put milk or sugar in their children's porridge, whereas the comparable proportions in the rural areas of other provinces ranged from only 16 per cent to 35 per cent. In Nyanza province milk was used much less frequently than in other provinces, but sugar use was reported by 58 per cent of mothers. Although the data on feeding practices are sparse, it appears that the feeding patterns in the rural areas of Coast province may be responsible for the high prevalence of malnutrition found in the national nutrition surveys. This high rate of early malnutrition may in turn be responsible for much of the excess infant mortality in this area. Data from the third national nutrition survey suggests that these problems in Coast province are concentrated in Kilifi and Kwale (and possibly Lamu) districts.

A different kind of evidence for the relationship between nutrition and mortality comes from the data on length of breast-feeding. Meru district was found to have a low infant mortality rate, 51, but an estimated ratio of infant deaths to deaths at ages 1-4 much lower than nearby districts with similar levels of mortality (e.g. Nyeri, Kirinyaga, Embu and Laikipia). The data from the third survey of nutrition in rural areas shows that women in Meru district breast-fed their children longer than women in any other district, an average of 23.1 months, and the 1977 nutrition survey showed that this long breast-feeding was common among the Meru tribe.

This pattern of breast-feeding is accompanied by other differences in child-feeding practices, including a relatively low proportion of children receiving whole milk and a large proportion receiving powdered milk. In Meru district only 61 per cent received whole milk as opposed to 75, 85 and 92 per cent in nearby Embu, Nyeri and Kirinyaga districts, respectively. On the other hand, 12 per cent received powdered milk in Meru as opposed to 8, 2 and 1 per cent in the other three districts. Only South Nyanza and Kisumu districts showed larger proportions receiving powdered milk (Kenya Central Bureau of Statistics, 1983:73-74). It is quite possible that some of the deaths that occur in the infant year in neighbouring districts could be postponed in Meru to later ages because of the long breast-feeding and the reliance on powdered milk could contribute to these problems during the second and third years of life.

A series of nutritional surveys undertaken by P. M. Mbithi and B. Wisner (quoted in Kenya Central Bureau of Statistics, n.d.:1-10) examined the relationship between child nutritional status and agricultural potential of land along a line extending from the eastern slopes of Mt. Kenya to the more arid flatlands. The six survey areas were spread along an altitude gradient and spanned a range from high to low agricultural potential. The results of the surveys showed that the proportion of children aged 3 years and younger who were less than 70 per cent of the standard weight for age increased from 10 to 38 per cent as the quality of agricultural land declined. The data were collected during a drought, which probably exaggerated the differences between the areas; however, it is clear that the areas with the poorest agricultural potential had a significantly higher proportion of severely malnourished children.

A comparison of some of the data from the three national surveys suggests that the proportion stunted at ages 1-4 years increased between 1977 and 1982 in rural areas of Western province (Kenya Central Bureau of Statistics, 1983:22-30). This proportion increased from only 16 per cent stunted in 1977 to 24 per cent in 1979 and 30 per cent in 1982. Although by 1982 Western province was very close to the national average (28 per cent) this evidence of increasing malnutrition is disturbing.

Attacking the problem of malnutrition must proceed on two fronts. The first entails efforts to raise agricultural productivity and incomes in general; the second must be nutrition education in those areas where supplemental feeding is inadequate or where children are weaned too early. The Ministry of Health has recognized the importance of nutrition education. It employed 237 nutrition field workers in 1979. These workers were assigned to 145 hospitals and 92 health centres. However, only about 8 per cent of the malnourished children received any treatment at nutrition clinics in 1979 (based on data from Kenya, 1982: 51).

Causes of death among adults and causes of death which affect both children and adults

This section discusses the main causes of death among adults as well as several causes that affect both children and adults, in particular malaria and tuberculosis. The division in developed countries between the causes of death among children and the causes among adults is not as sharp in Kenya and similar developing countries. For example, Drury has stated that in Uganda,

> ". . . the elderly die from diseases of childhood, such as infections, acute tuberculosis, neglect and malnutrition. Growing old usually does not bring the Ugandan an incurable disease, but continues to subject him to the same environmental risks that he becomes less capable of resisting" (Drury, 1972:391).

Although this statement probably understates the importance of cardiovascular disease and, at the oldest ages, cancer, the main point is valid.

The main distinction between children and adults is in the availability of useful data. Because of the high proportion of the population that are children and the high rates of incidence and mortality due to a few infectious diseases (pneumonia, gastro-enteritis, measles etc.), more research has been done on childhood diseases and mortality. In addition, the demographic techniques for estimating adult mortality levels are not as accurate as the methods used to estimate child mortality and the adult mortality estimates often apply to a time period many years before the survey. Despite this relative lack of information, it is possible to sketch the main causes of death and some major differentials in adult mortality.

Because of the relative lack of data on causes of death over age 5, we have utilized standard tables of cause of death prepared by Preston (1976). These tables are based on a collection of relatively reliable life tables, most of which come from Europe, Asia or South America. Preston grouped these tables according to the level of life expectancy, then produced a standard life table by cause by averaging the rates for each age, sex and cause for the tables in the group. The resulting tables are very useful since they give typical values for cause-specific mortality at different levels of overall mortality.

Since Preston found a reliable cause-specific life table for only one country in sub-Saharan Africa (Mauritius), these tables must be applied to African populations with caution. We have used his tables to judge whether the values suggested by the data on a few causes are reasonable, and to fill in gaps in the data. As there is very little reliable data on the variations in mortality due to most causes in high mortality countries (the most important exception is tuberculosis), and as the data on adult mortality are so sparse, all of the estimates in this section are probably less reliable than those in the section on child mortality.

Malaria. The data on registered deaths during the 1970s ascribe about 2 per cent of deaths to malaria and the percentage for individual districts rarely exceeds 3 per cent. Among in-patient deaths in 1978, 5 per cent were caused by malaria. In both data sets, the percentage of deaths ascribed to malaria was roughly twice as high at ages 1-14 as at other ages. In 1979, 20 per cent of the out-patient and 8 per cent of the in-patient cases were diagnosed as malaria. However, Roberts (1964:307) reported that "in many district hospitals more than 80 per cent of the cases diagnosed as malaria among out-patients are not confirmed by laboratory methods", and Rees (quoted in Roberts, 1964) showed that malaria was over-diagnosed in Nairobi.

In 1979 the percentage of out-patient cases that were diagnosed as malaria ranged from 6 per cent in Central province to 30 per cent in Nyanza and Western provinces. This wide geographic differential suggests that malaria might be responsible for some of the geographic differences in mortality. The regression analysis of district differentials in infant mortality found that diferences in malaria were highly correlated with child mortality estimates. This analysis suggests that in high mortality districts, eliminating malaria would reduce the infant mortality rate by 15 points. If an equal number of deaths were prevented at all other ages, malaria would be responsible for about 8 per cent of all deaths in districts with a high incidence of malaria.

There are several reasons to believe that the proportion of deaths caused by malaria is much smaller than suggested above and some reasons for believing that the proportion might be substantially larger. The case for a lower estimate is based on the following considerations:

(*a*) As noted above, malaria is frequently over-diagnosed;

(*b*) The regression results are questionable because the measure of malaria prevalence is the proportion of out-patient cases ascribed to malaria which is a poor measure of incidence. Also, when variables representing ecological zones are added to the regression, the malaria index is no longer significant. This suggests that the apparent effect of malaria might be a spurious result caused by the fact that the coast and lake districts have both high mortality and high malaria rates;

(*c*) An early study of the effects of malaria on Luo infants in Kisumu district by Garnham (1949:57) suggested that "young children of an African tribe living under conditions of malarial hyperendemicity and in a favorable circumstance are relatively unaffected" by malaria.

Evidence suggesting a larger share of deaths due to malaria comes from two studies of antimalarial spraying campaigns. The first of these studies was the Pare-Taveta scheme which measured mortality rates before, during and after spraying campaigns in two malarious areas in north-eastern Tanzania and south-eastern Kenya. Table 58 presents mortality trends for the Mkomazi Valley study area before, during and after eradication of malaria and for the Mamba zone which was always free of malaria.

TABLE 58. AGE-SPECIFIC MORTALITY RATES BEFORE, DURING AND AFTER A MALARIA SPRAYING PROGRAMME, MKOMAZI VALLEY OF TANZANIA, 1954-1966, AND COMPARISON VALUES FROM THE MALARIA-FREE MAMBA AREA, 1962-1966

Age	*Mkomazi Valley*				
	1954-1955 (Before spraying)	*1956-1957 (During spraying)*	*1957-1958 (During spraying)*	*1962-1966 (After spraying)*	*Mamba 1962-1966*
Infant mortality rate[a]	165	78	132	125	20
1-4	28	14	10	24	10
5-14	4	4	2	3	2
15-39	10	5	5	4	2
40+	27	15	13	16	14
Crude death rate[a]	24	12	16	15	6

Sources: 1954-1958: C. C. Draper, "Studies in malaria in man in Africa", unpublished thesis for D.M. degree, Oxon., 1962, tables 40 and 43; 1962-1966: G. Pringle and Y. G. Matola, *Report on the Pare-Taveta Vital Statistics Survey, 1962-1966* (Nairobi, East African Common Services Organization, 1967).

NOTE: Spraying began during 1955 and ended in 1959.

[a] Data for 1954-1958 from "Grade I Registers", i.e., those families studied prospectively for anthropometric and clinical tests.

Several points are clear from the data. First, with the initiation of spraying, mortality declined by about 40 to 50 per cent in all age groups, with the possible exception of 40 and over (table 58). Second, the cessation of spraying was followed by a substantial increase in mortality at ages 1-4 but not at other ages (Pringle, 1969). Finally, the malaria-free zone, Mamba, had much lower infant mortality than the malaria zone during the spraying campaign.

The drop in the crude death rate of 40 with the initiation of spraying suggests that malaria was responsible for a substantial proportion of deaths. This estimated proportion of death caused by malaria must be examined in the context of several observations.

(*a*) Maternity histories collected in these areas in 1955 suggest that a mortality decline was already underway. Draper (1962) shows that women aged 38-47 reported an infant mortality rate for their children of 262 per 1,000. Women aged 28-37 reported a rate of 212 and those aged 16-27 reported 185. As older women would have given birth, on the average, at an earlier time period, the data imply a mortality decline.

(*b*) Changes in measures of morbidity other than malaria show a mixed picture of the effect of spraying. The mean hemoglobin levels increased in all age groups with the elimination of malaria and dropped with the return of malaria; however, the level never returned completely to the pre-spraying levels. On the other hand, a study of school students and workers on large estates showed no decrease in absenteeism. More significantly, Draper and Draper concluded that "malaria control has had little effect on the mean African weights" among children (1960:167). Unfortunately, it is not possible to determine whether the small increase they noted in mean weights for age represented a general increase in the distribution of children by weight or whether the increase was concentrated among the least well nourished. A change of the latter sort would probably be related to a larger reduction in morbidity and mortality than a shift in the whole distribution.

(*c*) During the years of spraying, rice was being introduced into the malarious Mkomazi area as a cash crop. This led to a change in the economic status of the population and to the in-migration of young families from a "relatively enlightened upland community" (Pringle, 1969:S-3). These changes undoubtedly were associated with changes in mortality not directly associated with the elimination of malaria.

(*d*) There was apparently an increase in the use of commercially distributed modern anti-malaria drugs for the treatment of fever (Pringle, 1967). This may have limited the impact of the return of malaria on mortality.

(*e*) The malaria-free Mamba zone was not similar in all other ways to the Mkomazi valley. In particular Pringle (1969) notes that there were "wide differences also in their respective levels of prosperity and sophistication". This is not surprising since given a choice almost anybody would prefer to live in a cooler, fertile, non-malarious area rather than in a swampy, humid, malarious one. There are undoubtedly social and economic factors which determine who lives in the malarious area. It is likely that these factors and the economic differences associated with residence in a more fertile area are associated with differences in morbidity and mortality other than those associated with malaria. For example, these differences may explain some of the large difference in the infant mortality rates in the two areas, although some of this may be caused by under-reporting of infant deaths in the Mamba zone.

The second study of the impact of spraying on malaria and mortality was carried out in Kenya in an area west of Kisumu town on the shores of Lake Victoria (Payne, and others, 1976). The study covered a test area and a control area separated from each other by a barrier zone. The trends in the crude death rate for the two areas are shown in table 59. The data for the first year show that the areas were comparable before the initiation of spraying in September 1973. During the spraying, the treatment area had significantly lower mortality than either the control area or the pre-spraying level in the treated area. The two areas had exactly the same mortality rates up to three months of age during the spraying which suggests that infants are protected by maternal antibodies for the first months of life (Payne, and others, 1976). The difference between the infant mortality rates in the two areas is due completely to differences after the third month. In both the test and the control areas, infants who died had higher parasite rates than other infants.

TABLE 59. THE EFFECT OF MALARIA ERADICATION ON MORTALITY IN THE KISUMU AREA OF NYANZA PROVINCE, 1972-1975

	Crude death rate	
Period	*Untreated area*	*Treatment area*
Aug. 1972-Aug. 1973	23.3	23.9
Aug. 1973-Aug. 1974	25.7	16.0
Aug. 1974-Aug. 1975	24.4	13.6

Source: Payne and others, "Impact of control measures on malaria transmission and general mortality", *Bulletin of the World Health Organization,* vol. 54 (1976), p. 373.

NOTE: The first round of spraying in the treatment area was in August 1973.

The data from these two studies suggest that in some malarious areas the elimination of malaria might reduce the crude death rate by as much as 30 to 40 per cent with slightly larger declines at ages 1-14. Comparisons of the estimated rates for districts with the rates for the study areas are instructive. The infant mortality rate in the Kisumu study before spraying (157) is similar to the levels found in districts around the lake and along the coast. The infant mortality rate in the Mkomazi area during the first two years (213) is comparable to the estimates for the lake districts during the 1950s but much above the current levels. These comparisons suggest that the 30 per cent reduction in mortality found in the Kisumu study might be similar to the reductions to be expected in larger areas.

If it is assumed that (*a*) the proportion of deaths caused by malaria is proportional to the proportion of in-patient cases ascribed to malaria and that (*b*) in the most malarious districts 25 per cent of the deaths are due to malaria, then approximately 12 per cent of the deaths nationally would be due to malaria as a primary or underlying cause. Comparing this estimate with the data on registered deaths and the regression analysis, it can be estimated that elimination of malaria would reduce the national crude death rate by 8-12 per cent. It is important to note that the amount of mortality directly attributable to malaria might be much less than this estimate suggests.

Kenya has never attempted a national spraying campaign to combat malaria; however, smaller spraying programmes have been successful in reducing malaria in a few areas. In particular permanent anti-malaria control measures in Malindi (Coast province) have reduced the presence of malaria below levels found in neighbouring sub-districts. For example, among blood smears tested for malaria, only 4.5 per cent were positive in Malindi as opposed to 32 per cent in Ramisi, 28 per cent in Vanga and 17 per cent in Kilifi (Kenya, Ministry of Health, 1982). Similar programmes have been conducted in Lamu (Coast) and Chemase (Rift Valley). Although there have not been large-scale campaigns, it is possible that some of the decline in mortality in Nyanza and Western provinces in the past 20 years could be due to treatment of cases or suspected cases of malaria. This would include both treatment by government and private health care personnel as well as the use of commercially distributed anti-malarials which were suggested as a possible reason for the lack of a mortality surge when malaria returned to the Mkomazi Valley.

Cardiovascular diseases. The Registrar General's data for 1977 include 1,751 deaths medically certified as due to cardiovascular causes. The majority of these deaths (52 per cent) were of persons over the age of 50. If these deaths were reported with the same coverage rate as that for all medically certified deaths, the mortality rate over age 50 due to this cause would be 6.6 per 1,000 for males and 5.6 for females. These rates are less than half the levels indicated by Preston's standard patterns of cause of death. The same finding holds for the districts that have the highest proportion of deaths registered.

The only way to determine whether cardiovascular mortality is actually lower in Kenya than in other countries at similar levels of mortality is to examine the age pattern of mortality. Since cardiovascular deaths are an increasing proportion of deaths as age increases, the overall age pattern of mortality is quite sensitive to the level of cardiovascular mortality. A comparison of the age pattern of mortality implied by the registered deaths and Preston's standard patterns shows that the apparent shortage of reported cardiovascular deaths is not due to improper attribution of causes. The reported age pattern of mortality is very similar to what Preston's patterns would be if cardiovascular mortality was at half the expected level. Therefore it appears from the registered deaths that either cardiovascular mortality is actually lower in Kenya or else the cardiovascular deaths are not reported as completely as other deaths.

The other data that provide useful evidence of the age pattern of mortality at the oldest age is the data on parental survival from the 1969 and 1979 censuses. A comparison of the reported proportions deceased with Preston's patterns suggests that mortality in Kenya increases more rapidly at the oldest ages and not less rapidly as would be the case if cardiovascular mortality were low in Kenya. Although there are other potential explanations for the sharp rise in mortality at the oldest ages (for example, age misreporting among those aged 25-45 who report on survival of parents), it is unlikely that the real pattern of mortality at the oldest ages shows a slower rise than in Preston's tables.

Although there is very little evidence for or against a conclusion of lower cardiovascular mortality in Kenya, similarity between the estimated age pattern of mortality at the oldest ages and Preston's standard pattern suggests that cardiovascular deaths are less completely reported than other causes of death. This is consistent with the nature of cardiovascular deaths, which frequently are so sudden that there is no time to get medical treatment. Since most of the registered deaths occur in hospitals, low hospitalization rates would result in low rates of registered deaths. Because of this the true cardiovascular mortality rates in Kenya are probably closer to the values in Preston's cause of death life tables than to the rates implied by the data from the Registrar General's Office. It can therefore be estimated that there were about 23,000 deaths due to cardiovascular causes in 1977, about 160 per 100,000 population. This suggests that the coverage rate for cardiovascular deaths is about 7.6 per cent, much lower than the rate of about 14.9 per cent for deaths due to all other causes.

Cancer. The cancer registry data for Kenya for the period 1957-1963 show a rate of only 7 cases per 100,000 population (Linsell, 1967), far below the rate of about 280 reported for Norway in 1968-1972. There are three factors responsible for this large difference: under-reporting of cases in Kenya, differences in the age distributions of the two populations and possibly lower actual rates in Kenya. The cancer registry for Kyadondo County, Uganda (which surrounds Kampala), is much more complete than the Kenyan registry and reports an incidence of 48 cases per 100,000 population (Davies and others, 1965). If we standardize the Norwegian data using the Kenyan age distribution, we find a rate of 99 per 100,000.

Since the case-fatality rates due to cancer are very high, the Kyadondo incidence rates can be used to estimate that there are about 45-50 cancer deaths per 100,000 population in Kenya. This compares to a figure of 58 per 100,000 using Preston's standard for population with e_0 between 45 and 60. It appears therefore that the true value for Kenya is probably in the range of 45-55 cancer deaths per 100,000 population which amounts to about 4 per cent of all deaths.

Cancer deaths are unlikely to form a large proportion of deaths in the foreseeable future. Even with a slight increase in cancer mortality rates, substantial reductions in mortality due to other causes and a reasonable decline in fertility, cancer deaths will represent less than 6 per cent of all deaths in the year 2000.

Table 60 presents the data on cancer incidence by site and sex for Kyadondo county, Uganda, in the period 1968-1970. The reported rates are compared with the Norwegian rates standardized on the Kyadondo age

TABLE 60. ANNUAL CANCER INCIDENCE BY SITE AND SEX, KYADONDO, UGANDA, AND RATIO OF REPORTED TO RATE EXPECTED FROM NORWEGIAN STATISTICS FOR 1968-1972

		Males		*Females*	
ICCD[a]	*Site*	*Kyadondo, Uganda*	*Actual/ expected*	*Kyadondo, Uganda*	*Actual/ expected*
150	Oesophagus	2.5	1.9	3.6	11.2
151-154	Stomach, intestines, rectum	2.4	0.1	4.5	0.3
155	Liver	6.2	7.5	2.9	0.6
160-162	Lung, bronchus, trachea etc.	1.2	0.1	1.1	0.4
174	Breast	-	-	4.8	0.2
180-184	Cervix, uterus, ovaries etc.	-	-	19.7	0.9
185	Prostate	2.7	0.2	-	-
187.0	Penis	2.8	8.8	-	-
188	Bladder	2.4	0.5	0.4	0.3
200	Lymphomas	2.8	1.7	1.6	1.7
201	Hodgkins	1.6	0.8	0.4	0.3
204-207	Leukemias	2.2	0.6	3.6	0.7
	All other[b]	13.7	0.3	11.8	0.6
	Total[b]	42.7	0.4	54.8	0.6

Source: International Classification of Cause of Death, Eighth Revision.

[a] International Classification of Cause of Death.

[b] Excluding skin cancers listed under #173 in the International Classification of Cause of Death.

distribution. Although in general the reported rates for Kyadondo are much lower than the standardized Norwegian rates, males in Kyadondo show much higher incidence of cancer of the oesophagus, the liver and the penis and females have a much higher rate of cancer of the oesophagus.

Liver cancer in males is 7.5 times as frequent in Kyadondo as in Norway. The ratio for females is only 0.6. The resulting sex ratio (2.63) in Kyadondo is very similar to the reported value for Kenya (2.76) (Linsell, 1967). Liver cancer can easily be over-diagnosed because metastases from other sites frequently occur there (Lilienfeld, 1980); however, the lower than expected rate for females is not consistent with excessive over-diagnosis. Linsell (1974) discusses the possible links of liver cancer to aflatoxins (chemicals elaborated by fungus on stored cereals) and hepatitis.

The excessive incidence of oesophageal cancer in Kyadondo was also found in a study of cancer in Kisumu district (Ahmed and Cook, 1969). These elevated rates can appear in small areas and may be related to alcohol consumption (Linsell, 1974).

Cancer of the penis is probably less common in Kenya than in Uganda. The reason for this is that most tribes in Kenya practice circumcision which is related to reduced risk of cancer of the penis. This association is evident in data from Nairobi on the distribution by tribe of 27 cases of penile cancer; 17 of these cases were uncircumcised Luo (Dodge and Kaviti, 1965).

It is possible that the excess incidence of these three types of cancers can be reduced by public health programmes which change alcohol consumption (either the amount consumed or the type), circumcision practices and possibly the methods used for storing grain. Although all three of these approaches involve difficult changes in cultural patterns and would have little impact on overall mortality rates even if they were successful, this kind of approach to cancer in Kenya is probably more cost-effective than programmes to treat identified cancer cases.

We have estimated the age-specific cancer mortality rates by multiplying the age-site-specific mortality rates for Norway by the ratio of the reported incidence in Kyadondo to the incidence rate for Norway standardized on the Kyadondo age distribution. This amounts to making three simple assumptions. The first assumption is that the age pattern of incidence is the same for each site in Norway and Kenya. The second major assumption is that the case fatality rates are similar in Kenya and Norway and have remained relatively constant. The third assumption is that the incidence rates in Kyadondo are similar to those in Kenya.

We have relaxed one of these assumptions to produce a more likely estimate of Kenyan cancer mortality by averaging the reported Kyadondo site-specific case rate and the mortality rate based on case-fatality rates halfway between the rates in Norway and 100 per cent fatality. The ratio of this new mortality rate for a given site to the minimum estimate for that site can be applied to the age-site-specific rates estimated using the Norwegian rates. This produces estimates of age-site-specific mortality which can be added together to get a rough estimate of the age pattern for all cancers. These estimates will be used later in this discussion to estimate the effect of reducing cancer mortality.

Tuberculosis. It was estimated that in 1958 there were about 110,000 open and suspected cases of pulmonary tuberculosis in Kenyans over the age of 10 years. In addition, about 3 per cent of the children under age 5 and about 13 per cent of the children 5-9 were infected (Kent, 1974, p. 196; Ang'awa, 1965, p. 667). In 1962 a mass programme of BCG vaccination began in the school system and in 1962 and 1963 a total of 420,000 BCG vaccinations were administered.

In 1980, surveys of vaccination coverage in Nyeri and Kirinyaga districts showed coverage rates of 85 and 84 per cent for BCG (WHO Regional Office for Africa, 1982:36), and the annual number of BCG first doses is sufficient to cover approximately the same proportion of infants nationally (Kenya, Ministry of Health). This programme helped to reduce the estimated annual incidence rate from 400 in 1958 to 170-200 in 1969 (Kent, 1974, p. 200). In addition to the BCG programme, there has been considerable work done on designing and implementing effective programmes for treatment. Traditionally, the regimen for tuberculosis involved 12 to 18 months of drug therapy. Because of high default rates in the programme, the policy in the past five years has been to shift to a more expensive six month "short course".

Evaluation of the impact of tuberculosis programmes can be based on the national tuberculosis surveys conducted in 1964 and 1974 (East African and British Medical Research Council, 1974). Both surveys covered new, previously untreated cases reported in 10 districts: Nairobi, Muranga, Kilifi, Kwale, Kitui, Meru, Baringo, Kericho, Nakuru and Kakamega. They relied on the cases newly diagnosed in the existing health centres and therefore do not provide prevalence or true incidence rates. These surveys show very high default rates for both years. In 1964 only 28 per cent of the patients completed 12 months of drug therapy while in 1974 the figure was 24 per cent. However, there was apparently some improvement in the cure rate: the estimated negative culture rate after one year or more among patients who had bacteriologically confirmed disease increased from 63 per cent in 1964 to 71 per cent in 1974.

Although the rate of newly reported cases is only a crude measure of incidence (in 1958 it is estimated that nationally new registrations amounted to only 25 per cent of new cases (Kent, 1974), it provides some evidence that incidence has decreased. In 1964 in the 11 districts studied, the new case rate for pulmonary and extra-pulmonary tuberculosis was 74 per 100,000. By 1974 the rate had declined to 57 and the reported annual rate for these districts in 1978, the last quarter of 1979 and the first half of 1980 was only 47. Although these rates exclude many cases which were unreported, they also include some cases which were not confirmed bacteriologically. For example, in the 1974 survey the annual rate of registrations for tuberculosis was 57 while the rate for bacteriologically confirmed cases was only 36.

Table 61 suggests that most of the decline in the registration rate is due to the BCG programme since almost all of the decline between 1964 and 1974 was under the age of 25. Persons aged 25 in 1974 were aged 13 in 1962 and were therefore in the target group at the

TABLE 61. ANNUAL RATES OF REGISTRATION OF TUBERCULOSIS (RESPIRATORY AND NON-RESPIRATORY), PREVIOUSLY UNTREATED NEW CASES PER 100,000 POPULATION, 11 DISTRICTS, KENYA, 1964 AND 1974, BY AGE AND SEX

Age	Males			Females			Total		
	1964	1974	Percentage change	1964	1974	Percentage change	1964	1974	Percentage change
0-4	51	38	-25	60	36	-40	55	37	-33
5-9	40	17	-56	44	18	-58	42	18	-58
10-14	51	24	-53	60	20	-66	56	22	-60
15-19	63	36	-43	67	27	-60	65	32	-52
20-24	95	49	-48	72	60	-18	83	54	-34
25-29	115	104	-9	86	65	-25	99	84	-16
30-39	119	123	3	110	92	-16	115	108	-6
40-49	141	144	2	134	110	-18	138	127	-7
50-59	163	152	-7	76	102	35	122	128	5
60 and over	72	119	65	33	58	79	53	90	69
All ages	77	64	-17	70	49	-30	74	57	-23

Source: East African and British Medical Research Council, "Tuberculosis in Kenya: Follow-up of the second (1974) national sampling survey and a comparison with the follow-up data from the first (1964) national sampling survey", *Tubercule*, 60 (1978), pp. 172-173.

start of the BCG campaign. The increase in the registration rate over age 60 and the relative stability at 25-59 suggest that the ratio of registrations to new cases did not decline over the period in these districts, and therefore the decline in the rate of registrations probably reflects a true decline in incidence. In the light of this evidence, the stability of the national rate of notifications between 1964 and 1979 suggests improved reporting, probably in the form of reporting by a larger proportion of districts and a higher ratio of registrations to cases.

A minimum estimate of tuberculosis mortality can be derived by applying the one year survival rate for new cases from the 1974 tuberculosis survey, 80 per cent, to the 10,169 notifications of new cases in 1979. This leads to a minimum estimate of 13 tuberculosis deaths per 100,000 population. Since there is underreporting of new cases (Kent suggests one third reported in 1974) and since the default rate among new cases (about 75 per cent) suggests high mortality after the first year following notification, the true rate could easily be three or four times as large. This suggests an estimate of about 40 to 50 per 100,000.

In 1977, 6 per cent of the deaths reported to the Registrar General were attributed to tuberculosis, or 19 per 100,000 population. If we start with the tuberculosis deaths certified by medical personnel and assume that the coverage rate of these deaths is the same as for all other causes of death except cardiovascular and cancer, we derive an estimate of 32 per 100,000. This estimate is probably biased downward by the fact that the districts with the largest number of medically certified deaths probably have relatively low levels of tuberculosis, in particular, Central province and Nairobi.

For the 24 districts listed in table 54, we can adjust the number of medically certified deaths according to the district estimates of coverage of all except cardiovascular and cancer deaths. In six of these districts, this leads to fewer deaths than were actually reported to the Registrar General (medically and non-medically certified combined). Taking the maximum of the two estimates (total reported and adjusted medically certified) for each of these 24 districts, the authors ran a regression comparing the estimated mortality rate with the data on notification of new cases.* This regression was then used to estimate mortality for eight districts with data on notifications of new cases but no reliable data on mortality. For the remaining districts, which account for a small part of the total population, we assumed a case rate of 75 per 100,000 population. These calculations lead to an estimate of about 45 deaths per 100,000 population.

This estimate is below estimates based on Preston's standard patterns. Preston's standard for populations with life expectancy between 45 and 55 gives a rate of 89 respiratory tuberculosis deaths per 100,000 population with the Kenyan age distribution. His model for populations with e_0 between 55 and 65 gives 50 respiratory tuberculosis deaths per 100,000 population. Since about 90 per cent of tuberculosis cases are respiratory, even the 50 per 100,000 is about 25 per cent higher than our estimates of 45 for all tuberculosis mortality in Kenya.

A possible reason for the difference between the estimate for Kenya and the estimate based on Preston's patterns is the extensive BCG programme which has been operating in Kenya since 1962. If we take the average of Preston's patterns for e_0 of 45-55 and 55-65, we get an overall level of mortality very similar to Kenya's in 1977 (about 54 years). If we reduce the tuberculosis mortality rates by 50 per cent under age 30 and by 30 per cent at ages 30-34, we derive an estimate of 44 respiratory tuberculosis deaths per 100,000 population This rate is similar to an estimate based on respiratory tuberculosis rates in Hong Kong (41) at a similar point in its programme to reduce tuberculosis, in 1961 (Preston, Keyfitz and Schoen, 1972). It appears therefore that the estimate of 45-50 deaths per 100,000 for all types of tuberculosis is a very reasonable one given Kenya's BCG programme. Although the available data on mortality are not adequate to establish trends in tuberculosis mortality, the declining incidence rate under age 25 has probably been associated with a substantial decline in mortality under age 25 as well. If the decline in tuberculosis mortality under age 25 was similar to the decline in the registration rate under age 25, the overall mortality rate of tuber-

* This regression excluded Nairobi for which data on notification are not available, Mombasa where the rates are exaggerated by a tuberculosis hospital and Lamu where there were no reported deaths.

culosis probably declined by about 25 per cent between 1962 and 1977.

As in most populations, there is a substantial sex difference in the incidence of tuberculosis. In the 1974 study the annual rate of new registrations for tuberculosis was 30 per cent higher for males than for females. In the 1977 registered deaths, the reported death rate due to tuberculosis was 50 per cent higher for males for the total population and 70 per cent over age 25. These sex differentials in tuberculosis mortality are substantially larger than those reported in Preston's models; however, they are well within the range of international experience. For example, using the tuberculosis mortality rates for Hong Kong in 1961 (e_0 of 64) with Kenya's age distribution leads to a male mortality due to tuberculosis which is 2.8 times the rate for females.

The data from the notification of infectious diseases for 1979 (Kenya, Ministry of Health, August 1980: 15) and the reports of out-patient morbidity (Director of Medical Services, March 1982:25) show that tuberculosis is a very serious problem in Rift Valley and North-Eastern provinces (table 62). The rates of notified cases per 100,000 population for these two provinces are about 170, about two and a half times the national average. At the other extreme, Nyanza province reports relatively low levels of tuberculosis morbidity despite its relatively high level of mortality at all ages. In addition, low levels of infection in children aged 0-14 and a low rate of positive sputa were found in Nyanza in the 1959 prevalence survey (Roelsgoard and Nyboe, 1961).

The World Health Organization in its recommendations for anti-tuberculosis programmes has pointed out that BCG campaigns provide only a long-term solution to the problem. Although Kenya is beginning to approach the point where the proportion of the population that was protected by BCG might reduce mortality through a reduced pool of infectives, case finding and treatment must be the primary short-term approach to reducing tuberculosis mortality. In this regard, the development of the short-course (six month) regimen (Aluoch, 1979) research on the reasons for default (Ndeti, 1972), and evaluation of techniques for case-finding (Nsanzumuhire and others, 1981) provide a strong basis for the design and implementation of anti-tuberculosis programmes. In particular there has been a study of a treatment programme among the Somali nomads in Wajir district which combines short-course therapy with facilities for the patient's family to settle for six months in the neighbourhood of the clinic (Aluoch, 1979). This approach has greatly increased the success rate among the nomads and offers a useful model for reducing tuberculosis mortality in nomadic populations where it is most prevalent.

Motor vehicle deaths. Motor vehicle deaths are not a major cause of death, but they are relatively well reported because of the record keeping carried out by the Kenyan police. Raval (1974) calculates that there were about 55 motor vehicle deaths per 100 million miles of travel in Kenya in 1970. This compares with values of 6 for the United States and 13 for the United Kingdom at about the same time. Police records show that there were 1,338 motor vehicle deaths in 1975 (Statistical Abstract, 1976) which amounts to 10 per 100,000 population. In 1977, the Registrar General's Office reported 796 such deaths (6 per 100,000), but Raval's study demonstrates that in the early 1970s the Registrar General's figures were not as complete as those from the police.

TABLE 62. REGISTRATIONS OF NEW CASES OF TUBERCULOSIS BY DISTRICT AND REGION, KENYA, 1964-1979

	New cases per 100,000 population			
Province/district	*1964*	*1974*	*1978 4th quarter, 1979 1st half, 1980*	*1979*
Nairobi	198	118	. .	62
Central	. .	. .	22	32
Kiambu	. .	. .	15	. .
Kirinyaga	. .	. .	27	. .
Muranga	104	34	32	. .
Nyandura	. .	. .	30	. .
Nyeri	. .	. .	13	. .
Coast	. .	. .	97	38
Kilifi	74	62	26	. .
Kwale	107	103	37	. .
Lamu	. .	. .	38	. .
Mombasa	. .	. .	263	. .
Taita/Taveta	. .	. .	44	. .
Tana River	. .	. .	87	. .
Eastern	. .	. .	. .	44
Embu	. .	. .	37	. .
Isido	. .	. .	124[a]	. .
Kitui	65	67	41	. .
Machakos	. .	. .	23	. .
Meru	110	84	117	. .
North-Eastern	. .	. .	. .	169
Garissa	. .	. .	156	. .
Wajir	. .	. .	26[b]	. .
Nyanya	. .	. .	11	15
Kissi	. .	. .	3	. .
Kisumu	. .	. .	34	. .
Siaya	. .	. .	35	. .
S. Nyanya	. .	. .	4	. .
Rift Valley	. .	. .	. .	175
Baringo	30	33	. .	. .
Kajiado	. .	. .	128[a]	. .
Kericho	35	46	45[a]	. .
Laikipia	. .	. .	69[a]	. .
Nakuru	69	37	17[a]	. .
Narok	28	28	108[a]	. .
Samburu	. .	. .	39[a]	. .
Uasin-Gishu	. .	. .	15[a]	. .
Western	. .	. .	9	27
Bungoma	. .	. .	8	. .
Busia	. .	. .	5	. .
Kakamege	13	13	11	. .
Eleven survey districts	74	56	47	. .
TOTAL	66	. .	. .	66

Sources: 1964 and 1974: East African and British Medical Research Council, "Tuberculosis in Kenya: Follow-up of the second (1974) national sampling survey and a comparison with the follow-up data from the first (1964) national sampling survey", *Tubercle,* 60 (1978), p. 172.

Total for 1964: P. W. Kent, "Tuberculosis", *in* L. C. Vogel and others (eds.), *Health and Disease in Kenya,* 1979, Nairobi, East African Literature Bureau, 1979, p. 198.

1979: Kenya, Ministry of Health, Annual Report of out-patient morbidity, 1979, Nairobi, 1981a.

1980: Kenya, Ministry of Health, Out-patient report, 2nd quarter, 1980, Nairobi, 1981b.

NOTE: No data are available for Marsabit, Mandera, Elyeyo-Marakwet, Nandi, Trans-Nzoia, Turkana and West Pokot districts.

[a] Data for first half of 1980 only.

[b] No data for 1978.

Mortality due to motor vehicle accidents was highest in Nairobi and Mombasa (18 and 28 deaths per 100,000 population reported to the Registrar General in 1977) with high values recorded for Kiambu and Kisumu districts (16 and 13 respectively). Motor vehicle deaths accounted for 8.5 per cent of the deaths reported among males aged 15-24.

Maternal mortality. In 1978 there were 277 maternal deaths reported among the 85,372 in-patient admissions for conditions related to pregnancy. This amounts to a case-fatality rate of about 325 per 100,000. This rate differs from the maternal mortality rate which includes all deaths of pregnant women and deaths within 42 days of termination of pregnancy. It is difficult to determine whether the case-fatality rate among hospital in-patients is at all similar to the maternal mortality rate since hospitals may attract women who are more apt to have problems with delivery. However, this bias might be small in the absence of complete coverage by prenatal screening programmes. On the other hand, women who deliver in hospitals receive better medical care and are more apt to be higher-income, well-educated women living in cities.

In a study of maternal deaths in Kenyatta National Hospital in Nairobi, Makokha (1980) calculated a maternal mortality rate of 233 for 1976-1977. This rate is only a rough indicator of the maternal mortality rate for Nairobi for several reasons. First, only about 13 per cent of the live births in Nairobi were seen at the hospital. In 1979 there were 24 maternal deaths recorded in Nairobi while in 1976 and 1977 there were only 15 maternal deaths in the hospital. Therefore the maternal mortality rate for the whole city is probably lower than that in the hospital since a larger proportion of the deaths (probably as much as 30 per cent) occurred there. Second, the maternal mortality rate may be exaggerated since 31 per cent of the maternal deaths at Kenyatta National Hospital in 1972 were referrals of difficult cases from other hospitals.

In addition to being unrepresentative of the rate for Nairobi, the Kenyatta National Hospital maternal mortality rate is even less representative of all of Kenya. One important reason for this is the large proportion of the maternal deaths related to abortions. Among 99 maternal deaths at the Hospital in the period 1972-1977, 24 (24 per cent) were related to abortion, most of these involving post-abortal sepsis. Of these 24, 18 were women who reported their marital status as single (3 others did not report their marital status). This high rate of abortion-related maternal mortality is clearly a serious problem in Nairobi, but it is probably less prevalent in the rest of the country.

Despite these problems, the data from Kenyatta National Hospital provide a useful picture of the kinds of factors underlying maternal mortality in Kenya. For example, excluding the deaths related to abortion, 28 per cent were due to puerperal sepsis, 19 per cent to post-partum haemorrhage, 8 per cent to ruptured uterus, 4 per cent to women with tuberculosis and 3 per cent were related to cardiac disease. The figures on sepsis are probably over-stated because of the cases not clearly identified as related to abortion; 14 per cent showed signs of a possible attempt to abort.

The 1978 data on in-patient admissions for 23 districts distinguish between maternity cases with and without complications. The rate of complications among hospital in-patients was 21 per cent, which is far too high for the total population. In the Machakos study area, 3.2 per cent of the births were to women who had such problems of pregnancy as anaemia, malaria, toxemia, tuberculosis and heart disease. It is possible that the definition of complications might be different for the two data sets; however, we can standardize the reported case-fatality rate among in-patient admissions for a reasonable proportion with complications which will lower the estimated rate.

There are, however, biases that operate in the other direction. Since the in-patient data overrepresent districts with a relatively high concentration of dispensaries and hospital beds, the reported rate might be biased downwards as a national estimate. Data on in-patient admissions are available for 23 districts; however, in some districts the number of admissions for pregnancy are so small that the case-fatality rate is based on only two or three deaths.

Because of these problems, we have estimated the maternal mortality rate using the following procedure. First, the data on in-patient fatalities for the 23 districts were standardized to a 4 per cent complication rate. The estimated maternal mortality rates were then compared to a second set of estimates based on the number of reported deaths divided by an estimated number of births in the district. For the purpose of this estimation, the the number of births in each district was estimated from the population aged 0-4 and the estimated child mortality rates. The estimate of maternal mortality for each of these 23 districts was taken as the larger of these two estimates. The second step was to regress the estimates for the 23 districts on the percentage of out-patient cases diagnosed as malaria, the number of beds per 1,000 population and the reported incidence of tuberculosis. This regression equation was weighted by the number of in-patient admissions for conditions related to pregnancy in the district. The resulting equation was then used to estimate values for all of the remaining districts except Nairobi. For the purpose of making a national estimate, the value estimated for Mombasa was used for Nairobi. For 2 of the 23 districts, Garissa and Busia, there were no maternal deaths reported. For these two districts the in-patient estimates were replaced by regression estimates.

This procedure leads to an estimated maternal mortality rate of about 240 deaths per 100,000 live births which is equivalent to about 1,800 maternal deaths in 1979. This rate is based on rather sparse information, and it is probably a minimum estimate because it is based on hospital and dispensary deaths. It is likely that the true rate could be closer to 400 per 100,000 live births.

E. Cause of death structure and implications for health planning

Relative importance of causes of death

Table 63 summarizes the importance of each of the causes of death discussed in the previous sections. The major cause of death in Kenya is respiratory illness, particularly pneumonia. About three fourths of the respiratory deaths occur among children under the age of 5 and 90 per cent of these are due to pneumonia. Some of these deaths may be double-counted in the table because there may be some overlap in the estimates for respiratory and measles deaths. In addition, it should be noted that malnutrition was probably an underlying cause or even the true cause of death in most of the child deaths due to respiratory causes.

TABLE 63. SUMMARY OF CAUSES OF DEATH, KENYA, 1979

Rank cause	Code[a]	Percentage of total deaths	Thousands of deaths (1979)
1. Respiratory	89-96	19.5	35.5
2. Cardiovascular	80-88	13.0	23.7
3. Measles	25	8.0	14.6
4. Gastro-enteritis, diarrhoea	5	6.8	12.4
5. Malaria	31	6.0	10.9
6. Other infections and parasitic (ages 5 +)		4.4	8.0
7. Cancer	45-61	4.0	7.3
8. Tuberculosis	6-10	2.4	4.4
9. Tetanus (infants)	20	1.2	2.2
10. Maternal	112-118	1.0	1.8
11. Motor vehicle	E138	0.8	1.5
12. Pertussis	16	0.2	0.4
Subtotal		67.3	122.6
Other		32.7	59.6
TOTAL		100.0	182.2

[a] International Classification of Causes of Death, Intermediate list, 1965, revision.

The second most common cause of death is probably cardiovascular. Although the exact amount of mortality due to this cause is difficult to estimate, it is clear that the registered deaths understate its significance.

The third cause of death is measles. The estimate included here is based on the immunization figures up to 1980 and the importance of measles may have been reduced since then by the expanded programme of immunization.

The fourth most important cause of death is gastro-enteritis and dysentery. About three fourths of these deaths are children under age 5. The estimate for the population over age 5 is based on Preston's standard patterns of cause-specific mortality.

The fifth cause listed is malaria. In the discussion of malaria mortality, the authors estimated that reduction of malaria could reduce the national crude death rate by 8-12 per cent. Malaria is listed here as the main cause for 6 per cent of the deaths, since malaria is apt to have been an associated cause in many cases. This estimate is close to the 5 per cent of all in-patient deaths ascribed to malaria in 1978.

The next most common cause of death is other infectious and parasitic diseases in the population over age 5. This estimate is based on Preston's standard patterns and is therefore only a rough guess of the importance of these causes. Their importance is probably a reflection of general health conditions, the availability and utilization of modern health facilities and possibly malnutrition among the elderly. Reductions in this cause of death may be responsible for a significant part of the reductions in mortality during the next 10 years, and will certainly be important in reducing mortality among adults.

The low ranking of cancer mortality on this list is a direct consequence of the age distribution in Kenya. Mortality due to cancer is high only over age 50, and only 9 per cent of the Kenyan population is in this age group. Even with substantial declines in mortality due to other causes and with a relatively fast decline in the birth rate, the age distribution will not change sufficiently for cancer to become a major cause of death during the next few decades.

Tuberculosis ranks eighth on this list of causes; however, its susceptibility to programme intervention and the potential for reducing tuberculosis mortality make it a more important cause for health planning than its rank would indicate. Tuberculosis mortality apparently declined by about 25 per cent between 1962 and 1977. This decline will continue as a result of the continuing BCG program. However, faster declines will require an expanded programme of case identification and treatment.

Tetanus among infants is listed here as the ninth cause of death. This ranking is probably the least reliable. The possible frequency of this disease and the potential for its reduction through programme intervention underline the importance of determining its precise importance.

Maternal mortality ranks surprisingly low given the importance frequently given to it in health planning. Its ranking would not be substantially altered if we doubled our estimate of the maternal mortality rate to 500 per 100,000 live births. The importance of maternal mortality would be increased slightly if we consider the deaths of the infants born to women who die of complications of child bearing.

The low ranking of maternal mortality is largely due to the fact that only a small fraction of the population (females aged 15-49 who are pregnant) are at risk from this cause of death. The emphasis on this cause in health planning in many countries is partly explained by the fact that identification of pregnant women and new mothers is an important part of many programmes aimed at the prevention and treatment of infant and childhood diseases which are major causes of death.

The last two causes of death are very minor. Motor vehicle deaths are included because reasonably accurate data are available from police records. Pertussis is a disease that was probably far more important during earlier periods and its low ranking today reflects the impact of the extensive programme of vaccination.

The ranking of diseases given in table 63 is partly a reflection of the diseases for which we are able to estimate mortality rates. For example, malnutrition is probably an important cause of death and is certainly a major underlying and associated cause. However, it is very difficult to quantify the contribution of malnutrition to mortality.

Implications for selecting health programmes

Of more immediate relevance to health planning is the evaluation of the potential benefits of various health programmes. Although the authors cannot make recommendations on the appropriate priorities for health planning without evaluating the likely costs and the feasibility of each potential programme, several indicators of the likely benefits in terms of reduced mortality can be provided.

While no attempt has been made to estimate costs or to discuss specific types of programmes, the discussion below is based on estimates of the relative potential for decreasing each cause of death. For example, it is conceivable that measles mortality can be virtually eliminated with a reasonable expansion of the vaccination programme. On the other hand, it is unlikely that substantial reductions could be made in cancer mortality with the current state of knowledge about the prevention and treatment of cancer and the high cost of many existing treatment regimens. Therefore, a comparison of the potential impact of completely eliminating cancer and measles mortality would not be useful for planning purposes.

For this reason the authors have based all of the calculations of potential benefits on reasonable guesses of the potential reductions in mortality from each cause that could be achieved by a concerted programme effort over a period of two to five years. In each case, it is possible to extrapolate from these estimates to estimate the impact of programmes that have larger or smaller effects than indicated by the assumed percentages. For example, the calculations on cancer are based on a 2.5 per cent reduction in cancer mortality. Because of the mathematics of eliminating a cause of death from a life table, the increase in e_0 from a 50 per cent reduction in cancer deaths will be larger than 20 times the effect of a 2.5 per cent reduction. However, within the range of zero to 20 per cent, the change in the life expectancy can be assumed to be proportional to the assumed reduction.

The largest assumed potential reduction is the value for measles, 80 per cent. This is the assumed reduction in measles mortality at all ages with the values in table 63 as the base. The value of 80 per cent represents virtual elimination of measles through expanded vaccination coverage. Because of the difficulty of achieving complete coverage, we have not assumed complete elimination of measles mortality. However, achieving a high coverage rate in every part of the country will lead to an increased average age of measles incidence which will result in a lower case-fatality rate. The effect of complete elimination of measles can easily be approximated by multiplying the impact measures by 1.25.

The potential reduction in malaria is very difficult to estimate since we are not even sure of the amount of mortality associated with malaria. The calculations of potential impact are based on the assumption that complete elimination of malaria would reduce mortality by 8 per cent at ages 1-4, 10 per cent at ages 5-14 and 6 per cent at all other ages. This estimate is therefore based on minimal estimates of the amount of mortality related to malaria. The potential reduction used in calculating impact is 10 per cent. This is based on a programme of presumptive chemotherapy for fever cases in hyperendemic and holoendemic areas. The likely impact of such a programme is almost impossible to guess even if it achieves 100 per cent coverage in programme areas. The 10 per cent figure is selected merely for illustration and provides a reasonable ranking of the relative importance of malaria.

The most likely kind of programme for reducing diarrhoea mortality is one based on oral rehydration therapy (ORT). Whether based on prepackaged mixtures of sugar and salts or on home preparations based on locally available materials, the success of such a programme depends on changing the traditional approaches to treatment of diarrhoea. The studies that have attempted to measure the impact of ORT in field programmes provide little guidance on the likely impact. One reason for this difficulty is that the impact will depend on both the acceptance of the method by the population and on the complex interactions between diarrhoea and other causes of death. The assumed 10 per cent reduction is a reasonable estimate for national impact of a programme which would probably be more successful in some areas than in others. Adherents of ORT programmes might expect a larger impact in areas in which the programme is successfully administered and where diarrhoea is an important cause of child mortality.

The assumed reduction in tuberculosis mortality of 15 per cent is in addition to the reductions that will result from the continuing BCG programme. It is therefore based on a programme of case findings and treatment. The best index of the size of the programme required to achieve this reduction is that it would lead to a saving of about 100 lives per year. This would require an expansion of the current (1979) level of new cases by at least 30 per cent. Since this would involve more intensive case finding or an increase in the use of the short-course therapy, it would probably involve an increase in cost and effort in excess of 30 per cent.

The assumed reduction in maternal mortality by 25 per cent would be better stated as a reduction in the maternal mortality rate by about 55 points per 100,000 live births since our estimate of the maternal mortality rate is probably an underestimate. Although it is difficult to estimate the size of the programme needed to achieve this reduction, it would require a substantial increase in the number of deliveries in hospital and more extensive pre-natal screening. The estimated number of lives saved from this programme, 450 per year, suggests a substantial increase in the number of Caesarean deliveries and the number of deliveries receiving transfusions and antibiotics.

The assumed reductions in cancer and cardiovascular mortality are the most difficult to estimate. The cost of treating cancer cases and the relatively low success rates imply that it is unlikely that health programmes in Kenya can reduce cancer mortality substantially. Although control of blood pressure through diet and chemotherapy can reduce cardiovascular mortality, it would require a substantial programme of health education, blood pressure screening and follow-up care to reduce cardiovascular mortality substantially. Therefore the estimate of a 5 per cent reduction in cardiovascular mortality and a 2.5 per cent reduction in cancer mortality have been selected for illustration.

It is important to state once again that these assumptions about the possible impact of health programmes on these causes are not adequate for a complete cost-benefit-risk analysis of proposed programmes. Complete health planning should include more careful specification of programme design, costs and likely success rate as well as considering more cost-effective integrated programmes that would attack a number of causes. It is also important to note that several potential programme approaches have not been considered here at all. The most important of these are programmes designed to change the nutritional status and feeding practices for infants and children.

The selection of health programmes based on the potential impact of mortality can be affected by the choice of the measure of impact used. For example, two common measures of impact are the number of lives saved and the change in the life expectancy. In Kenya, a reduction of the mortality rate at age 0-4 by 1 per 1,000 will receive about 7.6 times as much weight in an estimate of lives saved as the same reduction for the age group 50-54, which has a population 7.6 times smaller. However, if change in the life expectancy is used as the criterion for comparison, the change at age 0-4 will receive a weight only about twice as large as a comparable change at age 50-54. Therefore, if two programmes are selected which affect causes of death with very different age distributions, the comparison of the programmes can depend on the index of impact selected. (For a complete discussion of these issues, see Ewbank, 1984).

Table 64 presents five measures of potential impact for each of the major causes of death. The first indicator is the estimated number of lives saved with the assumed reduction in each cause. For example, we have assumed that measles could be reduced by 80 per cent which would lead to a saving of about 9,100 deaths. This measure is directly proportional to the assumed reduction in mortality so that a 40 per cent reduction in measles mortality would lead to half as many lives saved.

The second measure of impact is the person-years of life saved (PYLS). If we save the life of a person aged 10, that individual will probably live for many more years while if we save the life of a person aged 80, he will probably die within the next 10 years of a different illness. Therefore saving the life of a child will add more person-years of life to the population. The person-years of life can be calculated using the formula:

$$\text{PYLS} = \Sigma\ N(x,x+n)\ E(x+n/2,i,e)$$

where $N(x+,x+n)$ is the number of lives saved at ages x to $x+n$ and $E(x+n/2,i,e)$ is the life expectancy of someone at the middle of the age interval x to $x+n$ using the life table with mortality to cause of death i reduced by the proportion e. This index obviously gives a lot of weight to the saving of a child's life since life expectancy at the youngest ages is relatively high. In addition, this index is affected by the age distribution of the population since the number of lives saved at any given age is a function of the size of the population at that age. Within reasonable limits, this measure is approximately proportional to e, the assumed change in the mortality rates to the cause.

The third index is designed to be more consistent with the economist's notion of benefits. Since a benefit received today is more valuable than a benefit that will not be received for 20 years, economists generally discount benefits to present values using an assumed discount rate. The same thing can be done by assuming that a person-year of life gained by eliminating a cause of death has less value if it will not be lived for many years. For example, saving the life of an infant will add about 57 person-years lived to the population. One of those years will be lived next year and one will be lived 50 years from now. The year lived 50 years from now is worth less than the year of life gained next year. The relative value of the year lived 50 years from now is assumed to be $exp(-50r)$ where r is the assumed discount rate, while the year of life lived next year is valued at $exp(-r)$. The discounted person-years of life added by reducing a cause of death can be calculated using the equation:

$$\text{DPYLS} = \Sigma\ N(x,x+n)\ DE(x+n/2,i,e)$$

where $DE(x,i,e)$ is the discounted life expectancy at age x when cause i is reduced by the proportion e. $DE(x,i,E)$ can be caluclated using the equation:

$$DE(x,i,e) = \Sigma\ exp(-r(y+n/2)\ {}_nL_y)/1_x$$

where ${}_nL_y$ is the life table person-years lived at ages y to $y+n$ in the life table with cause i reduced by e.

TABLE 64. MEASURES OF THE IMPACT OF REDUCING THE MAJOR CAUSES OF DEATH, KENYA, 1979

Cause	*Assumed percentage reduction*	*Lives saved annually (thousands)*	*PYLS (thousands)*	*DPYLS (thousands)*	*De_0*	*De_{20}*
Measles	80	9.1	556.1	87.1	0.87	0
Malaria	10	1.2	56.5	10.5	0.14	0.07
Diarrhoea	10	1.2	73.2	11.4	0.11	0
Tuberculosis	15	1.0	34.6	8.9	0.17	0.18
Cardiovascular	5	1.2	20.6	7.7	0.17	0.19
Maternal	25	0.5	9.5	4.3	0.07[a]	0.08[b]
Cancer	2.5	0.2	3.6	1.2	0.04	0.025

NOTE: PYLS = Person-years of life saved.
DPYLS = Discounted person-years of life saved.
De_0 = Discounted life expectancy at birth.
De_{20} = Discounted life expectancy at age 20.

[a] Change in female e_0 divided by 2.03.

[b] Change in female e_{20} divided by 2.00.

The calculation of the discounted person-years of life saved (DPYLS) obviously depends on the assumed discount rate, r. There is considerable discussion in the economics literature about the appropriate choice of a discount rate. For purposes of illustration, we have used a rate of 10 per cent.

The discounted person-years of life saved will give less weight to the saving of children's lives since many of their person-years of life will be many years in the future, whereas virtually all of the person-years of life added with the saving of the life of an 80-year old person will be within the next 10 years. With r equal to 10 per cent, the value of $DE(x,i,e)$ in Kenya is virtually constant at 9.6 years between ages 1 and 50. Therefore the value of DPYLS is approximately 9 to 9.5 times the number of lives saved except for causes that are concentrated over age 50.

The fourth measure of potential programme impact is the estimated change in the life expectancy at birth, e_0, from a reduction of mortality to cause i. Following the notation introduced above, this is $E(0,i,e) - E(0,i,0)$. This measure indicates the increased life expectancy of an infant born in Kenya if there are no further reductions in mortality during the infant's life time. It is an overall measure of the risks of mortality facing individuals in the country. It does not reflect the number of individuals affected by reducing the various risks and therefore is not affected by the age distribution of the population.

The fifth measure is the change in the life expectancy at age 20, i.e., $E(20,i,e) - E(20,i,0)$. Since comparisons of the other indexes of potential programme impact lead to the recommendation that health programmes should be aimed at infants and children, it is useful to ask which health programmes for adults are likely to have the biggest impact. The change in life expectancy at age 20 is the simplest measure of the change in the mortality risks facing adults. The choice of age 20 is rather arbitrary, however, because mortality rates are very low at ages 10-30; the ranking of programmes on the basis of change in life expectancy at ages 10 and 30 would probably give very similar results.

Table 64 presents these indicators for seven causes of death: measles, cancer, tuberculosis, childhood diarrhoea, cardiovascular, malaria and maternal. This list is limited to major causes of death for which estimates of the age-cause-specific death rates are available. For example, malnutrition which is potentially a target for health programmes, has not been included because of the difficulties of establishing the amount of mortality associated with it.

The calculated values in table 64 are all rough approximations since they depend both on the assumed reduction in the cause of death and on the estimates of the age-cause-specific mortality rates. However, the rankings of the causes are very revealing. Reduction of measles mortality has by far the largest impact according to each of the six indexes of impact with the exception of the change in e_{20}. Even if it were assumed that measles mortality could only be reduced by 20 per cent, reduction of measles would still rank highest on all of these indexes. The second and third highest rankings are given to reduction of malaria and childhood diarrhoea on all of the measures except e_0 and e_{20}. There are two reasons for the high ranks given to measles, malaria and childhood diarrhoea. First, these diseases are childhood diseases and therefore affect the largest age groups in the population. In 1979 about 19 per cent of the population was under age 5. Second, by affecting the youngest ages, the person-years saved and the discount person-years saved per life saved are at their maximum values. Both of these factors apply to any childhood disease.

Among the adult causes of death, maternal mortality, which is often linked with childhood diseases in a maternal and child health approach to programme delivery, ranks quite low on all of the measures despite the fact that we based the calculations on a 25 per cent reduction of mortality. This reflects the fact that maternal mortality is responsible for only 1-2 per cent of all deaths.

Cancer mortality reduction also ranks very low. The reason for this is that cancer mortality rates only become significant in the oldest age groups which contain a relatively small proportion of the population. In 1979 only 9 per cent of the population was over age 50. Because of the high average age of cancer deaths, each life saved from cancer only adds 20.3 years of life to the person-years of life saved, while each life saved from tuberculosis adds 34.6 years of life.

The impact of the assumed reductions in cardiovascular and tuberculosis mortality are very similar for all of the six indicators with the exception of the PYLS. Although we have assumed that tuberculosis mortality could be reduced by 15 per cent while cardiovascular mortality could only be reduced by 5 per cent with a comparable effort, the high mortality rates due to cardiovascular causes estimated above compensate for the different levels of reduction. Using the PYLS measure, we find that reducing tuberculosis by 15 per cent saves almost 70 per cent more lives than reducing cardiovascular deaths by 5 per cent. The reason for this is that each life saved from tuberculosis adds an average of 34.6 years of life while each life saved from cardiovascular mortality adds only about half as much, 17.7 years. This is caused by the difference in the average age of persons dying from cardiovascular diseases which is substantially higher than the average age of persons dying from tuberculosis.

It is important to note that the effects of a potential tuberculosis programme are the effects of additional efforts above those currently being carried out. For example, the estimate for tuberculosis does not include the ongoing BCG programme which is required to maintain the current levels of tuberculosis mortality under age 20.

Table 64 provides support for the strong concentration of health programmes on infant and child health. Childhood diseases rank high on all of the measures in the table with the obvious exception of change in e_{20}. There are three reasons for this. First, there tend to be relatively inexpensive, effective technologies for preventing or combatting childhood diseases. This is partly due to the fact that the major causes of death among children are infectious diseases which are generally responsive to modern medicine (e.g. immunization, antibiotics etc.) and to simple changes in diet, feeding practices and sanitation. This set of factors is reflected in Table 64 in the relatively high values of e, the potential decrease in the cause of death from likely levels of programme inputs.

The other two factors which lead to high potential impact from infant and child health programmes are more purely demographic and mechanistic, namely the age distribution effects and the higher life expectancies at the younger ages. Because of its high fertility rate, Kenya has a very young age distribution. Therefore any programme that affects children will have an effect on a larger proportion of the total population. In addition, since the life expectancy decreases with age (after 5 or 10), saving the life of a child adds more years of life to the population than saving the life of an adult.

The age distribution effect on measures of impact leads to a particularly striking result if we examine the potential effects of various health programmes on the crude death rate (CDR). Because a successful family planning programme will reduce the proportion of the population in the age group 0-4, it would probably rank very high in terms of its effect on the CDR even though it would probably have little effect on age-specific mortality rates.

The net result from these three factors is that programmes aimed at childhood diseases tend to have high ratios of benefits to costs. This would hold true of programmes aimed at other diseases not included in table 64. In particular, programmes designed to reduce malnutrition and to improve feeding would probably rank very high on the list if it were possible to estimate their likely impact on age-specific mortality rates.

The high level of benefits associated with reducing infant and childhood diseases is complemented by the fact that programmes to reduce these diseases can be carried out simultaneously, thereby reducing their costs. Although we have estimated the benefits of reducing measles, malaria and diarrhoea separately, all three of these can be combined with general immunization and basic nutrition education in a general maternal and child health programme (MCH). MCH programmes designed to carry the basic services outside of the clinic to small villages have proven to be highly cost-effective in many countries. Some of the more simple programme components (e.g., presumptive treatment of fever with chloroquine, basic health education on oral rehydration, nutrition and family planning) can be carried out by village-level health workers with a minimum of training. If these workers encourage women to seek prenatal care, identify children in need of nutrition rehabilitation and rally children for immunization campaigns, they can greatly increase the effectiveness of local health clinics and dispensaries.

Another way in which the cost-effectiveness of programmes can be enhanced is to place them in areas where the mortality rates are especially high. For example, in a well-nourished relatively healthy population a case of measles is not apt to be fatal; therefore a measles immunization programme in such an area will probably save few lives. However, a measles immunization programme in an area of high malnutrition and high mortality due to related diseases might save far more lives. These increased programme benefits in high mortality areas will frequently outweigh the additional costs that are sometimes required to run programmes in high mortality areas. It is likely that MCH programmes in areas with high rates of malnutrition and high population density will have substantial cost-benefit advantages over programmes in other areas.

The likely effect of including morbidity

The estimates given in table 64 cover only a part of the benefits from health programmes designed to reduce the significance of these diseases. In particular they ignore the benefits associated with reduced morbidity. Although the purpose of this report is to study mortality in Kenya, it is useful to speculate on the effects of including days of life lost to morbidity associated with each of these diseases. There are numerous problems involved with estimating the morbidity associated with various diseases and with producing an index which combines days lost to premature death and days lost to illness. One study which has tackled this problem is the study of mortality and morbidity conducted by the Ghana Health Assessment Project Team (1981). Since the data available on mortality and morbidity in Ghana are comparable in quality to those in Kenya, and the overall health situations in the two countries are similar, we can illustrate the likely effect of adding morbidity to our measures of impact using the Ghana estimates. In particular, the Ghana team reports the percentage of the days of healthy life lost which are due to premature death for 48 causes of death. We can use their estimates of this percentage to inflate the estimates of lives saved, PYLS and DPYLS in table 64. The results of this exercise are given in table 65. Although the inclusion of morbidity increases the relative impact of reducing cardiovascular rates and malaria, it does not substantially alter the ranking of these diseases. The most important effect is the increased relative benefits from reducing malaria.

TABLE 65. ESTIMATED HEALTHY DAYS OF LIFE SAVED AND DISCOUNTED HEALTHY DAYS OF LIFE SAVED, MAJOR CAUSES OF DEATH, KENYA, 1979

	Assumed percentage due to premature deaths[a]	*Assumed percentage reduction in mortality*	*Healthy days of life saved (thousands)*	
			Total	*Discounted*
Measles	96.6	80	575.7	90.2
Malaria	54.1	10	104.5	19.5
Diarrhoea	93.3	10	78.5	12.2
Tuberculosis	94.6	15	36.6	9.4
Cardiovascular	66.3	5	31.1	11.5
Maternal	82.6	25	23.6	5.2
Cancer	92.5	2.5	3.9	1.3

[a] Assumed percentage of total healthy days of life lost that result from premature loss of life; estimates from the Ghana Health Assessment Team, 1981.

Other considerations for health planning

The calculation of the potential impact of health programmes in terms of the likely saving of lives is an important tool in health planning. However, the impact on national mortality or morbidity levels is not the only consideration that should determine the selection of programmes. One other criterion that might be used is to give priority to those diseases that are responsible for large geographic differentials in mortality. In Kenya, this would probably increase the priority given to anti-malarial programmes which would have a larger effect in the coastal and western areas of the country, and to nutrition programmes which would be most important in coastal areas.

To some extent these priorities would come out of a complete cost-benefit analysis since programmes aimed at infant and child mortality have a larger potential impact in those areas where the infant and child rates are highest. However, the importance of reducing geographic differentials is an important goal in itself and should be used as one criterion for selecting programmes.

F. Overview

Summary of findings

Kenya has experienced a substantial, sustained decline in mortality for at least 35 years. Although it is clear that several health programmes have contributed to this decline (in particular immunization programmes), there is no evidence that the general availability of health facilities has been responsible for much of the decline. Instead most of the decline seems to be associated with general socio-economic development and related cultural changes. This is most clear in the relationship between education and mortality.

Education, like most successful development programmes, seems to have two different effects. The first is the knowledge directly imparted and the resulting changes in standard of living. The second effect is more difficult to demonstrate but probably more important in the long run. This is a general change in outlook that predisposes one to look beyond tradition and traditional opinion leaders to form or accept new ideas and new ways of doing things. Schooling apparently accomplishes this by (*a*) introducing a new authority figure, the teacher, whose authority comes from outside the traditional cultural system, (*b*) by teaching reading which opens up access to other sources of modern information, (*c*) by imparting knowledge to the child which may not be known to his parents or elders, and (*d*) at higher levels of education by making the child a part of a new social group, the group of classmates, which shares knowledge and experiences which may not be shared by parents and other members of the traditional elite.

In a similar way, a health programme can both provide services and encourage cultural changes related to health care. The cultural changes associated with a health programme might be as basic as instilling the idea that a child's health is not a matter of fate or magic; it is determined to a great extent by the way in which the child is fed and cared for. This change goes well beyond merely imparting information about diet and hygiene; it involves abandoning some traditional beliefs about the limits of human action and the inevitability of certain outcomes.

The geographic differentials in mortality reflect the importance of socio-economic development. Even after controlling for differences in education, the per capita availability of high potential agricultural land, population density and the availability of roads, Coast, Nyanza and Western provinces still show a clear disadvantage in mortality. In the case of Nyanza and Western provinces the excess in infant mortality after controlling for other factors is especially large, about 60 infant deaths per 1,000 live births in 1979.

Geographic differences in mortality are to be expected because of differences in culture, environment and history; however, it is surprising that these differentials have in some cases become worse. While most of the country has experienced substantial mortality declines, Coast province has had little or no decline in infant and child mortality. Therefore its mortality level has worsened relative to the rest of the country. In Nyanza and Western provinces there have been substantial declines in the past 20 years; however, the mortality level in these provinces is still much higher than the national average.

Some of the excess mortality in Coast and Nyanza is due to high mortality rates associated with malaria and diarrhoea. Although health programmes can be designed to combat these diseases, the effectiveness of these programmes will be limited unless economic development in these areas has reached the point where it can sustain the social and cultural change necessary to reduce these diseases. Programmes to combat childhood diarrhoea rely on changing the patterns of infant care and feeding, and malaria programmes based on presumptive chemotherapy require changes in attitudes towards the important symptoms of illness and the appropriate responses. Both of these programmes depend on a willingness to accept new approaches to problems that may not have been clearly perceived previously.

Because of the interrelationship between social and cultural change in such areas as health, education and agriculture, the Ministry of Health's efforts to deal with the health problems of Coast, Nyanza and Western provinces as well as more isolated areas of the country will be hampered if development programmes of other kinds are not also working to stimulate general development in these areas. In areas with low population density that are far from population centres, such as Isiolo, Baringo, Turkana and North-Eastern province, the health programmes are also hampered by such basic development needs as roads and electrification.

The excess mortality in Coast and Nyanza provinces is not only a problem of equity in risks of dying; it is a matter of continuing overall progress for the country. Those areas of the country that have reached an infant mortality rate under 60 and a life expectancy over 60 are not going to see their mortality rates declining as rapidly as they have in the past. These areas have come close to eliminating the deaths that can be prevented easily through immunization, simple curative measures, improved sanitation etc. For example it is very unlikely that Nyeri will see its infant mortality rate decline by 14 points during the 1980s as it did during the 1970s. The reason for this is that reducing the infant mortality rate from 38 to 24 is more difficult than reducing it from 52 to 38. The future prospects in Nyeri can be contrasted with those in Coast and Nyanza provinces where declines of the same magnitude (14 points in infant mortality) during the 1980s would be a disappointment.

If Kenya's mortality rate is to continue the rapid declines of the past 35 years, a large part of future declines will have to be concentrated in Coast, Nyanza and Western provinces. Most other areas of the country either have lower rates which will be difficult to decrease as rapidly, or they are sparsely populated and have little impact on national trends.

Implications for health planning

Although future mortality trends will depend on social and economic changes in many aspects of daily life in Kenya, the Ministry of Health has responsibility for those government programmes that are designed specifically to improve the health of the population. Therefore, it is important to examine the implications of this review of mortality for the design of health programmes. There are five general conclusions that can be drawn from the preceding analysis. None of them will be a surprise to anyone who has worked in the health field in Africa, but each general finding and the specific details underlying it has important implications for health planning.

The first general finding is the large geographic differentials in mortality. Although these differentials cannot be overcome solely by successful health programmes, the most cost-effective approach to reducing the national mortality rates will probably involve concentrating on those causes of death that are most common in these disadvantaged areas. Whether programmes are actually targetted to these areas or whether they are national programmes aimed at diseases that are most prevalent in these areas, the impact will depend on the degree of success they have in high mortality areas which contain a substantial fraction of the country's population.

The second general finding is the high correlation between mortality rates and education both at the district level and at the level of the individual household. This finding leads to two recommendations for health planning. The first is that a large proportion of the people who are the target of health programmes have sufficient education to open them to accepting new ideas from non-traditional sources, e.g. teachers, medical personnel and radios. Careful use of this potential receptivity of new ideas can be an important element in the success of health programmes centred on new approaches to health care such as oral rehydration, infant feeding, and treatment of malaria and tuberculosis. Since educated people appear to accept modern practices that reduce their mortality rates, health programmes can take advantage of this receptivity in designing new approaches.

A second policy implication of the importance of education is that persons with more than three years of education seem to be acting in ways that reduce their risks of dying. Since the regression analysis suggests that the effect of education is separate from the effects of income and the availability of health services, persons with even a few years of education must be changing their behaviour. These changes probably include changes in the utilization of health services as well as changes in hygiene, child-feeding practices, and self treatment of disease including use of medicines available outside of the formal health services, e.g. chloroquine. The fact that these new modes of behaviour can have such a noticeable impact on mortality suggests that some of these behaviours might be taught to uneducated persons. Research on the impact of education on the use of health services, child-feeding practices, hygiene and treatment of illness might provide clues as to simple strategies for health education. One example of this is the research done by Maina-Ahlberg (1979) in the Machakos area.

It is very easy to overstate the importance of education. For example, the change in education at the district level has not been closely related to the change in mortality (table 46). However, it seems that health education and other forms of informal education might be able to substitute for formal education in reducing mortality.

A third general finding is that the only formal public health programmes which have been shown to have had an impact on mortality are the immunization programmes. One reason for this has been pointed out by Mosley (1983). He notes that it is rarely considered necessary to run a field trial or a risk-benefit-cost analysis of hospital-based technologies. Therefore there are few studies designed to measure the impact of these programmes. This is in contrast to the extensive studies of programmes to reduce malaria and attempts to measure the impact of immunization, nutrition, health education and oral rehydration programmes that are being carried out in Kenya and many other countries. However, it is surprising to note that the regression analyses of district mortality estimates for both children and adults have failed to show any correlation with the availability of health services. This is especially important since Kenya is probably reaching the point where the potential gains from expansion of the immunization programmes will not lead to further substantial reductions of current mortality levels, and new programme designs will be needed to continue the rapid declines.

A fourth generalization comes from the analysis of potential improvements in life expectancy and the person-years of life saved from possible reductions in various causes of death. This analysis points out the central importance of reducing infant and childhood mortality. In particular, reduction of malaria and childhood infectious diseases like measles and diarrhoea will have much bigger impacts on mortality than comparable inputs into reducing such adult diseases as tuberculosis, cardiovascular mortality, maternal mortality and cancer. Some of these childhood diseases can be prevented by immunization and others can be treated effectively without sophisticated medical technologies, and many are related to problems of child feeding and malnutrition. Therefore, programmes to combat these diseases can be designed to rely minimally on hospital- and dispensary-based technologies.

The final generalization is the central importance of nutrition and child-feeding practices in determining infant and child mortality rates. The available evidence suggests that variations in such factors as the age at introduction of food supplementary to breast milk, the type of supplementary foods, their preparation and the frequency of feedings might be responsible for a substantial part of the excess child mortality in some areas of the country. Although it is difficult to measure the exact importance of these practices to mortality differentials with the available data, programmes to improve child-feeding practices should be an important part of future health planning for Kenya.

Taken together, these five generalizations lead to the suggestion that health planning for Kenya should move in the direction of programmes designed to deal with the problems of childhood infectious diseases, particularly diarrhoea, and the related problems of child-feeding practices. These programmes should be expanded beyond the confines of hospitals and dispensaries in order to reach children whose mothers have little or no education and children residing in the areas which have the highest mortality rates and which have shown the smallest declines during the past 25 years.

The health programmes of the past 20 years which have emphasized services provided through health centres and immunizations have definitely contributed to the rapid declines during that period. However, as mortality due to measles, whooping cough, tuberculosis and diptheria become less important, health services will have to expand into different kinds of programmes if they are to continue to contribute to the declines in mortality.

These recommendations are quite general and leave many policy questions unanswered. For example, there are many different approaches to programmes for teaching home-based oral rehydration therapy as well as alternatives to rehydration programmes such as nutrition education and malaria treatment and prevention. However, the evidence reviewed here does provide a firm basis for choosing the overall goals of health policy for the next decade.

Although these broad generalizations seem quite clear, there are many details that are still unknown. The estimates of cause-specific mortality are often very imprecise and often based on data from only a small proportion of districts and reporting only a small proportion of total deaths. The wide variety of demographic and epidemiologic data available for Kenya is unusual in Africa and provides a great deal of information for planning purposes. However, there is a need for careful research into a few particular topics of concern for health planning. For example, the importance of child-feeding practices is apparent at several stages of the preceding analysis, but there has been little research on the exact nature of child-feeding practices in different parts of the country. The national nutrition surveys have sketched out the broad outlines, but more detail is needed before appropriate health programmes can be designed to deal with these problems. Similarly, the possible importance of neonatal tetanus along the coast and in Western province needs to be investigated since it is easily prevented through immunization of all women of child-bearing ages.

Fortunately, Kenya's history of careful demographic and epidemiologic research continues today. Ongoing research on ways of improving the registration of deaths, on the nature of child-feeding practices in various parts of the country, and on alternative approaches to the control of malaria are just a few of the areas of ongoing research. The results of this research will aid in refining the evaluation of potential benefits, costs and risks of various kinds of health programmes. If this research is used in the health planning process, it is likely that Kenya's mortality decline will continue at its current rapid rate.

Annex

PROCEDURES FOR THE ESTIMATION OF MORTALITY TRENDS

The estimated mortality rates given in table 42 are based on data from the censuses of 1962, 1969 and 1979. The estimation procedures outlined below were applied to the data for each district separately and estimates for provinces and for the whole country were derived by aggregating the district estimates. For some districts it was necessary to vary the basic procedures because of obvious errors in the data or because the results seemed inconsistent with results from similar neighbouring districts. The most substantial deviations in procedure will be mentioned after a description of the basic procedures.

The decision to base these estimates on census data rather than on data from a variety of sources (e.g. registered deaths, fertility surveys) was based on several considerations. First, we were interested in estimates at the district level that enabled us to study geographic differentials and to examine the coverage of death registration. Only the census data provide useful information for every district with substantial sample sizes. Second, the censuses provided the longest time series of data. By linking the three censuses estimates could be derived of child mortality for the period from about 1950 to 1979. The time frame provided by the census data was far greater than that provided by any other study or series of studies.

The census data used here are the child survival data from the three censuses and the parental survival data from the censuses of 1969 and 1979. The procedures are modifications and extensions of standard procedures described in United Nations *Manual X* (1983) and Brass (1975). We have not tried to describe each method in detail, only to describe the outlines and the differences between our procedures and those discussed in *Manual X*.

Estimation of infant and child mortality

The 1962, 1969 and 1979 censuses provide data on the average number of children ever-born to women of various ages and the number of those children who were still living. The proportion deceased for each age group of women can be used to estimate child survival to a given age. The data from the first seven age groups of women (15-19, 20-24, ..., 45-49) provide estimates of the proportion surviving to ages 1, 2, 3, 5, 10, 15 and 20. The estimation of the proportions deceased by these ages, $q(x)$, has been estimated using the North model multipliers (United Nations, 1983:77).

Each of the $q(x)$ values estimated from the reports of child survival can be considered as an estimate for a given time period preceding the census. Since the children born to women aged 45-49 at the time of the census were born during the preceding 35 years, on the average their mortality experience precedes the experience of the children born to women aged 20-24 at the time of the census. By using estimation equations (United Nations, 1983: 78), an estimate can be made of the time period to which each $q(x)$ applies. For example, the $q(2)$ estimate for the 1979 census generally applies to the middle of 1977 while the $q(20)$ estimate from the same census generally applies to early 1965. The $q(x)$ estimates from the 1969 census apply to a period about 10 years before the time period for the same $q(x)$ from the 1979 census.

The $q(x)$ estimates have been adjusted slightly to take into account the fact that the Brass estimates based on the reports of young women are biased by the distribution of their children by birth order. In most populations, first births to young women have higher mortality risks than births of orders 2-5. The lowest mortality risks are experienced by second and third order children born to women aged 20-29. Although the factors determining the risks of child mortality seem to be more closely related to maternal age than to birth order, it is much easier to adjust the Brass type of estimates for differences in birth order.

The procedure we have used is very similar to that used by Ewbank in a study of child mortality in Bangladesh (1982). Data on infant mortality by birth order were available for a part of Bangladesh. This made it possible to adjust the Brass estimates for the relative differences in survival for children of different birth orders. The distribution by birth order of the children born to women of a given age can be derived from the distribution of the women by parity since, for example, each woman of parity 7 had one first birth, one second etc. Therefore, by combining the distribution of the births by birth order with estimates of the relative risks for children of each birth order it is possible to estimate the bias in each Brass estimated $q(x)$.

In the case of Kenya there are no estimates of the relative mortality risks facing children of different birth orders. Therefore, the authors have used a series of estimating equations based on all of the available reliable data on infant and child mortality by birth order in developing countries. The equations include an estimate of the age-specific fertility rate of women aged 15-19 to help estimate the relative risk of first births, since the risk for first births is higher when child-bearing begins early. Similarly, the age-specific fertility rate for women aged 40-44 is used as an indicator of the age of mothers who have the higher order births (6 and higher). In addition the relative risks at orders 4 and 5 seem to be related to the level of mortality as indicated by the infant mortality rate.

The procedure sketched above was used to adjust the Brass type of estimates of $q(2)$, $q(3)$ and $q(5)$. Because of their general unreliability the Brass type of estimates of $q(1)$, which are based on the reports of women aged 15-19 are not used in the estimation of mortality trends. Estimates of $q(10)$, $q(15)$ and $q(20)$ were not adjusted for birth order differences since these estimates are based on a mix of children of all birth orders and are therefore relatively unaffected by this problem. The adjustments for birth order are generally quite small, but they do seem to lead to a more consistent picture of mortality levels and trends.

Applying these procedures to the three censuses provides 18 estimated $q(x)$ values for each district (excluding the estimates of $q(1)$). As each of these estimates applies to a different time period, they can be used to estimate trends in mortality. The procedure generally used to study trends is to use model life tables to turn each of the $q(x)$ estimates into an estimate of the infant mortality rate. The problem with this approach is that the resulting trend depends on the choice of the model. As we know little about the actual age pattern of mortality in Africa, we can only guess which model is apt to be appropriate.

An alternative approach is based on the use of the logit transformation. If p is a proportion, then the logit of p, Y, is defined as $0.5 ln(p/1-p)$. Brass has demonstrated that life tables can be compared with a standard life table using a linear relationship between the logits of the proportions deceased at each age. In the linear equation the intercept, a, is related to the general level of mortality while the slope, b, is related to the age pattern of mortality. If we assume that the level of mortality as indicated by a has been changing linearly over time, we can relate the logits of our 18 Brass $q(x)$ values, $Y(x)$, to the logits of a standard life table $Ys(x)$, using the equation

$$Y(x) = a + b\,Y^s(x) + c\,T(x) \qquad (1)$$

where $T(x)$ is the time period to which the estimate of $q(x)$ applies.

This equation is not useful if data are available from only one census or survey since the $Y^s(x)$ and $T(x)$ values are so highly correlated that regression analysis does not provide useful estimates of b and c. However, with data from three sources separated by approximately 10 years, the values of $Y^s(x)$ and $T(x)$ are sufficiently uncorrelated that reasonable estimates of b and c can be derived. For example, for the standard we have used and the time periods to which our 18 estimates apply the correlation is only 0.51. Once we have fitted equation (1) using regression analysis, the equation can be used to derive estimates of any $q(x)$ values for any time period.

We have tested the application of this equation to our data using the North and the West model life tables. The choice between the two is unimportant since the value of b compensates for almost all of the differences between the two models under age 20. We have selected North model 12 since this is approximately the level of mortality for part of the period.

The procedures outlined above can be applied to many districts without any apparent problems. There are, however, three complications which arose for several districts. The first is that the boundaries for many districts changed between the 1962 and 1969 censuses. In many cases we could aggregate several districts to derive comparable areas for all three censuses. The estimate of b from these aggregates was then used as a check on the estimates of b for the separate districts based on the data from 1969 and 1979.

A second complication is that in a few districts the data from the 1962 census are clearly affected by underreporting of deceased children. For example, in some districts the reported proportion deceased increased substantially between 1962 and 1969. In these cases it was necessary to rely on only the data from the 1969 and 1979 censuses. In a couple of cases it was necessary to assume a value of b and estimate c from the data from 1979. In this case, assuming a value of b is comparable to selecting one of Coale and Demeny's models except that we have chosen from a wide variety of possible values of b instead of merely selecting one of the four models.

Estimation of adult mortality

The 1969 and 1979 censuses provide data on the survival of mother and father by age of respondent. In addition, the 1979 census provides tabulations by age and sex of respondent for each district. These data provide our best opportunity to estimate mortality over age 20.

The procedures we have used to estimate adult mortality are based on procedures described by Brass. These methods use the proportion of mothers surviving for persons in the five-year age group centred on age x to estimate the proportion of women surviving from age B, an age near the mean age of child-bearing, to age $x+B$. In life table notation this proportion is l_{x+B}/l_B. Similarly, the data on survival of parents is used to estimate the proportion $l_{x+2.5+B}/l_B$ where B is chosen to be close to the mean age at paternity. The values of B for the two sexes are based on the values of the mean age at child-bearing for the two sexes, M_f and M_m. M_f was estimated from the data on births reported in the census for the 12 months preceding the census. M_m was estimated as M_f plus the difference between the average ages of all married males and all married females in the census.

The estimates of the proportion surviving between age B and age $x+B$ or $x+B+2.5$ must be turned into standard life table proportions deceased since birth before they can be linked with child survival estimates to produce full life tables. In order to do this we have used a procedure suggested by Blacker (Brass, 1975:105). This approach is an iterative procedure based on a logit life table. It begins with a crude estimate of l_B. Multiplying the estimate of l_{x+B}/l_B by the estimate of l_B gives an estimate of l_{x+B}. Comparing this estimate of l_{x+B} with the estimate of l_{20} from child survival gives an estimate of the slope of the logit line, b, which relates the data to the standard. Using this estimate of b, the child survival estimate of l_{20} and the standard life table, we can derive a new estimate of l_B. With this new estimate of l_B we begin a second iteration. This procedure usually converges very quickly on final estimates of l_B, b, and l_{x+B}.

Our approach differs from the usual method in that it uses the child survival estimate of l_{20} instead of the estimate of l_2. There are two reasons for this change. The first is that the child survival estimate of l_{20} applies to very nearly the same time period as most of the parental survival estimates. This obviates the need for accurate estimates of the time trends. The second reason is that starting the procedure at age 2 requires the assumption that the life table has the same age pattern of mortality as the standard used for the logit comparison. By beginning the procedure with age 20, we only assume that the life table and the standard have the same age pattern over age 20.

The procedure outlined above was applied to the data from the 1979 census for each sex in each district and to the national data from the 1969 census. We relied solely on the reports of parental survival given by females since these data are probably less seriously affected by age misreporting.

At the national level it is possible to use the parental survival data from the 1969 and 1979 censuses together to estimate the level of adult mortality between the two census dates. This follows a procedure suggested by Preston (1983) and is based on the work on quasi-stable population analysis. The method is based on the idea that if the population with a surviving parent grows faster than the population with a deceased parent, then mortality rates must be declining. The national estimates of adult mortality and of e_0 are consistent with the district estimates. Life tables at the national and provincial level are presented in the following tables.

Age	Males								
	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.09493	.08900	100 000.	8 900.	93 756.	.89268[a]	5 563 149.	55.631	0.298
1	.01282	.04960	91 100.	4 519.	352 583.	.95715[b]	5 469 394.	60.037	1.385
5	.00533	.02630	86 581.	2 277.	427 214.	.97972	5 116 811.	59.098	2.500
10	.00284	.01410	84 304.	1 189.	418 550.	.98532	4 689 596.	55.627	2.500
15	.00318	.01580	83 116.	1 313.	412 405.	.98135	4 271 046.	51.387	2.584
20	.00439	.02170	81 802.	1 775.	404 716.	.97694	3 858 641.	47.170	2.580
25	.00488	.02410	80 027.	1 929.	395 383.	.97458	3 453 925.	43.159	2.535
30	.00545	.02690	78 099.	2 101.	385 332.	.97109	3 058 542.	39.163	2.543
35	.00634	.03120	75 998.	2 371.	374 191.	.96598	2 673 210.	35.175	2.555
40	.00756	.03710	73 627.	2 732.	361 462.	.95966	2 299 019.	31.225	2.558
45	.00901	.04410	70 895.	3 126.	346 882.	.95018	1 937 557.	27.330	2.571
50	.01164	.05660	67 769.	3 836.	329 600.	.93501	1 590 675.	23.472	2.590
55	.01562	.07530	63 933.	4 814.	08 180.	.90835	1 261 075.	19.725	2.614
60	.02355	.11150	59 119.	6 592.	279 933.	.86432	952 895.	16.118	2.624
65	.03589	.16530	52 527.	8 683.	241 952.	.79178	672 962.	12.812	2.618
70	.05937	.25940	43 844.	11 373.	191 573.	.55553[c]	431 010.	9.830	2.569
75	.13561	. .	32 471.	32 471.	239 437.	. .	239 437.	7.374	7.374

Age	Females								
	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.08592	.08100	100 000.	8 100.	94 273.	.89940[a]	5 930 508.	59.305	0.293
1	.01314	.05080	91 900.	4 669.	355 425.	.95776[b]	5 836 234.	63.506	1.392
5	.00506	.02500	87 231.	2 181.	430 705.	.98073	5 480 809.	62.831	2.500
10	.00270	.01340	85 051.	1 140.	422 404.	.98587	5 050 103.	59.378	2.500
15	.00306	.01520	83 911.	1 275.	416 437.	.98341	4 627 699.	55.150	2.556
20	.00363	.01800	82 636.	1 487.	409 529.	.98112	4 211 262.	50.962	2.547
25	.00398	.01970	81 148.	1 599.	401 797.	.97925	3 801 733.	46.849	2.533
30	.00443	.02190	79 550.	1 742.	393 461.	.97675	3 399 936.	42.740	2.539
35	.00502	.02480	77 807.	1 930.	384 311.	.97306	3 006 475.	38.640	2.551
40	.00595	.02930	75 878.	2 223.	373 958.	.96825	2 622 164.	34.558	2.557
45	.00702	.03450	73 655.	2 541.	362 084.	.96179	2 248 206.	30.524	2.565
50	.00870	.04260	71 113.	3 029.	348 249.	.95150	1 886 122.	26.523	2.584
55	.01147	.05580	68 084.	3 799.	331 359.	.93254	1 537 873.	22.588	2.615
60	.01693	.08140	64 285.	5 233.	309 005.	.90234	1 206 514.	18.768	2.627
65	.02493	.11770	59 052.	6 950.	278 827.	.84943	897 509.	15.199	2.636
70	.04164	.18930	52 102.	9 863.	236 845.	.61718[c]	618 683.	11.875	2.601
75	.11062	. .	42 239.	42 239.	381 838.	. .	381 838.	9.040	9.040

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

LIFE TABLES, NAIROBI, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.06399	.06100	100 000.	6 100.	95 321.	.92719[a]	6 206 576.	62.066	0.233
1	.00773	.03030	93 900.	2 845.	368 273.	.97317[b]	6 111 254.	65.083	1.425
5	.00365	.01810	91 055.	1 648.	451 154.	.98606	5 742 981.	63.072	2.500
10	.00195	.00970	89 407.	867.	444 866.	.98981	5 291 828.	59.188	2.500
15	.00223	.01110	88 539.	983.	440 332.	.98678	4 846 962.	54.744	2.594
20	.00312	.01550	87 557.	1 357.	434 512.	.98340	4 406 630.	50.329	2.589
25	.00353	.01750	86 200.	1 508.	427 298.	.98126	3 972 118.	46.080	2.547
30	.00406	.02010	84 691.	1 702.	419 289.	.97835	3 544 820.	41.856	2.553
35	.00473	.02340	82 989.	1 942.	410 213.	.97417	3 125 531.	37.662	2.564
40	.00578	.02850	81 047.	2 310.	399 617.	.96884	2 715 318.	33.503	2.568
45	.00696	.03420	78 737.	2 693.	387 166.	.96119	2 315 701.	29.411	2.579
50	.00905	.04430	76 044.	3 369.	372 139.	.94856	1 928 535.	25.361	2.601
55	.01235	.06000	72 675.	4 361.	352 995.	.92794	1 556 396.	21.416	2.619
60	.01814	.08700	68 315.	5 943.	327 558.	.89077	1 203 401.	17.615	2.642
65	.02922	.13670	62 372.	8 526.	291 779.	.82620	875 843.	14.042	2.645
70	.04876	.21830	53 845.	11 754.	241 067.	.58726[c]	584 064.	10.847	2.604
75	.12272	. .	42 091.	42 091.	342 997.	. .	342 997.	8.149	8.149

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

LIFE TABLES, CENTRAL PROVINCE, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.04671	.04500	100 000.	4 500.	96 332.	.94162[a]	6 693 146.	66.931	0.185
1	.00788	.03090	95 500.	2 951.	374 477.	.97599[b]	6 596 814.	69.077	1.451
5	.00282	.01400	92 549.	1 296.	459 506.	.98918	6 222 336.	67.233	2.500
10	.00153	.00760	91 253.	694.	454 533.	.99209	5 762 830.	63.152	2.500
15	.00171	.00850	90 560.	770.	450 936.	.99015	5 308 297.	58.616	2.579
20	.00227	.01130	89 790.	1 015.	446 493.	.98799	4 857 361.	54.097	2.578
25	.00254	.01260	88 775.	1 119.	441 129.	.98663	4 410 869.	49.686	2.543
30	.00286	.01420	87 657.	1 245.	435 229.	.98492	3 969 740.	45.287	2.545
35	.00325	.01610	86 412.	1 391.	428 666.	.98229	3 534 511.	40.903	2.560
40	.00394	.01950	85 021.	1 658.	421 075.	.97874	3 105 845.	36.530	2.570
45	.00471	.02330	83 363.	1 942.	412 122.	.97348	2 684 770.	32.206	2.584
50	.00617	.03040	81 421.	2 475.	401 193.	.96429	2 272 648.	27.912	2.612
55	.00859	.04210	78 945.	3 324.	386 868.	.94884	1 871 455.	23.706	2.635
60	.01288	.06250	75 622.	4 726.	367 076.	.91944	1 484 587.	19.632	2.666
65	.02164	.10300	70 895.	7 302.	337 505.	.86627[c]	1 117 511.	15.763	2.676
70	.03715	.17080	63 593.	10 862.	292 369.	.62517[c]	780 006.	12.266	2.643
75	.10814	. .	52 732.	52 732.	487 637.	. .	487 637.	9.248	9.248

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

LIFE TABLES, COAST PROVINCE, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.13369	.12300	100 000.	12 300.	92 005.	.85654[a]	5 179 076.	51.791	0.350
1	.01638	.06280	87 700.	5 508.	336 266.	.94346[b]	5 087 071.	58.005	1.361
5	.00683	.03360	82 192.	2 762.	404 058.	.97426	4 750 805.	57.801	2.500
10	.00355	.01760	79 431.	1 398.	393 659.	.98176	4 346 747.	54.724	2.500
15	.00392	.01940	78 033.	1 514.	386 478.	.97793	3 953 088.	50.659	2.565
20	.00504	.02490	76 519.	1 905.	377 949.	.97377	3 566 611.	46.611	2.562
25	.00553	.02730	74 614.	2 037.	368 037.	.97128	3 188 662.	42.736	2.530
30	.00615	.03030	72 577.	2 199.	357 466.	.96772	2 820 625.	38.864	2.537
35	.00702	.03450	70 378.	2 428.	345 927.	.9281	2 463 159.	34.999	2.545
40	.00818	.04010	67 950.	2 725.	333 062.	.95697	2 117 232.	31.159	2.546
45	.00952	.04650	65 225.	3 033.	318 730.	.94784	1 784 170.	27.354	2.562
50	.01213	.05890	62 192.	3 663.	302 104.	.93300	1 465 440.	23.563	2.583
55	.01597	.07690	58 529.	4 501.	281 863.	.90756	1 163 336.	19.876	2.605
60	.02351	.11130	54 028.	6 013.	255 806.	.86551	881 473.	16.315	2.616
65	.03533	.16290	48 015.	7 822.	221 403.	.79615	625 667.	13.031	2.613
70	.05757	.25250	40 193.	10 149.	176 270.	.56397[c]	404 264.	10.058	2.567
75	.13178	. .	30 044.	30 044.	227 994.	. .	227 994.	7.589	7.589

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

LIFE TABLES, EASTERN PROVINCE, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.07492	.07100	100 000.	7 100.	94 767.	.91145[a]	5 968 287.	59.683	0.263
1	.01138	.04420	92 900.	4 106.	360 959.	.96363[b]	5 873 520.	63.224	1.408
5	.00439	.02170	88 794.	1 927.	439 152.	.98325	5 512 561.	62.083	2.500
10	.00235	.01170	86 867.	1 016.	431 794.	.98776	5 073 409.	58.404	2.500
15	.00266	.01320	85 851.	1 133.	426 510.	.98471	4 641 615.	54.066	2.579
20	.00353	.01750	84 717.	1 483.	419 990.	.98145	4 215 106.	49.755	2.574
25	.00392	.01940	83 235.	1 615.	412 199.	.97945	3 795 116.	45.595	2.538
30	.00441	.02180	81 620.	1 779.	403 729.	.97676	3 382 917.	41.447	2.543
35	.00504	.02490	79 841.	1 988.	394 345.	.97271	2 979 188.	37.314	2.556
40	.00607	.02990	77 853.	2 328.	383 585.	.96760	2 584 842.	33.202	2.561
45	.00716	.03520	75 525.	2 658.	371 158.	.96079	2 201 257.	29.146	2.567
50	.00901	.04410	72 866.	3 213.	356 604.	.94878	1 830 099.	25.116	2.595
55	.01237	.06010	69 653.	4 186.	338 338.	.92613	1 473 495.	21.155	2.629
60	.01891	.09050	65 467.	5 925.	313 346.	.88906	1 135 156.	17.339	2.639
65	.02913	.13630	59 542.	8 116.	278 584.	.82350	821 810.	13.802	2.643
70	.05033	.22450	51 427.	11 545.	229 414.	.57768[c]	543 225.	10.563	2.599
75	.12709	. .	39 881.	39 881.	313 812.	. .	313 812.	7.869	7.869

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

Life tables, North-Eastern province, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.11269	.10500	100 000.	10 500.	93 175.	.87783[a]	5 344 492.	53.445	0.350
1	.01344	.05190	89 500.	4 645.	345 742	.95393[b]	5 251 317.	58.674	1.361
5	.00533	.02630	84 855.	2 232.	418 696.	.97982	4 905 575.	57.811	2.500
10	.00280	.01390	82 623.	1 148.	410 245.	.98571	4 486 880.	54.305	2.500
15	.00310	.01540	81 475.	1 255.	404 383.	.98009	4 076 635.	50.036	2.616
20	.00504	.02490	80 220.	1 997.	396 333.	.97334	3 672 252.	45.777	2.613
25	.00562	.02770	78 223.	2 167.	385 767.	.97088	3 275 919.	41.879	2.533
30	.00623	.03070	76 056.	2 335.	374 534.	.96704	2 890 152.	38.000	2.539
35	.00723	.03550	73 721.	2 617.	362 191.	.96158	2 515 618.	34.124	2.549
40	.00849	.04160	71 104.	2 958.	348 276.	.95494	2 153 427.	30.286	2.551
45	.01006	.04910	68 146.	3 346.	332 582.	.94495	1 805 151.	26.489	2.565
50	.01283	.06220	64 800.	4 031.	314 272.	.92834	1 472 569.	22.725	2.587
55	.01733	.08320	60 769.	5 056.	291 750.	.89997	1 158 297.	19.061	2.607
60	.02555	.12040	55 713.	6 708.	262 567.	.85399	866 547.	15.554	2.615
65	.03881	.17760	49 005.	8 703.	224 229.	.77727	603 980.	12.325	2.610
70	.06396	.27660	40 302.	11 148.	174 288.	.54105[c]	379 750.	9.423	2.558
75	.14190	. .	29 155.	29 155.	205 463.	. .	205 463.	7.047	7.047

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.
[b] Value given is for S(0,5) = L(5,5)/L(0,5).
[c] Value given is S(70+,5) = T(75)/T(70).

Life tables, Nyanza province, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.12429	.11500	100 000.	11 500.	92 525.	.86194[a]	5 097 837.	50.978	0.350
1	.01742	.06660	88 500.	5 894.	338 445.	.94136[b]	5 005 312.	56.557	1.361
5	.00723	.03550	82 606.	2 933.	405 698.	.97260	4 666 866.	56.496	2.500
10	.00384	.01900	79 673.	1 514.	394 582.	.98022	4 261 168.	53.483	2.500
15	.00426	.02110	78 160.	1 649.	386 777.	.97623	3 866 585.	49.470	2.562
20	.00539	.02660	76 510.	2 035.	377 584.	.97190	3 479 808.	45.481	2.559
25	.00597	.02940	74 475.	2 190.	366 974.	.96891	3 102 224.	41.654	2.533
30	.00669	.03290	72 286.	2 378.	355 564.	.96522	2 735 251.	37.839	2.534
35	.00752	.03690	69 907.	2 580.	343 198.	.96006	2 379 687.	34.041	2.543
40	.00885	.04330	67 328.	2 915.	329 490.	.95350	2 036 488.	30.247	2.547
45	.01031	.05030	64 413.	3 240.	314 168.	.94328	1 706 999.	26.501	2.563
50	.01329	.06440	61 173.	3 940.	296 348.	.92635	1 392 830.	22.769	2.585
55	.01768	.08480	57 233.	4 853.	274 522.	.89881	1 096 483.	19.158	2.601
60	.02575	.12130	52 380.	6 354.	246 743.	.85173	821 961.	15.692	2.615
65	.03964	.18100	46 026.	8 331.	210 159.	.77771	575 218.	12.498	2.603
70	.06264	.27160	37 695.	10 238.	163 442.	.55229[c]	365 060.	9.684	2.555
75	.13618	. .	27 457.	27 457.	201 618.	. .	201 618.	7.343	7.343

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.
[b] Value given is for S(0,5) = L(5,5)/L(0,5).
[c] Value given is S(70+,5) = T(75)/T(70).

Life tables, Rift Valley province, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.07821	.07400	100 000.	7 400.	94 613.	.90584[a]	5 823 499.	58.235	0.272
1	.01300	.05030	92 600.	4 658.	358 307.	.95919[b]	5 728 886.	61.867	1.404
5	.00486	.02400	87 942.	2 111.	434 435.	.98143	5 370 579.	61.069	2.500
10	.00262	.01300	85 832.	1 116.	426 369.	.98647	4 936 145.	57.510	2.500
15	.00292	.01450	84 716.	1 228.	420 600.	.98328	4 509 776.	53.234	2.575
20	.00386	.01910	83 487.	1 595.	413 568.	.97964	4 089 176.	48.980	2.574
25	.00433	.02140	81 893.	1 753.	405 150.	.97740	3 675 608.	44.883	2.538
30	.00484	.02390	80 140.	1 915.	395 992.	.97450	3 270 458.	40.809	2.541
35	.00553	.02730	78 225.	2 136.	385 896.	.97038	2 874 466.	36.746	2.551
40	.00654	.03220	76 089.	2 450.	374 464.	.96498	2 488 571.	32.706	2.558
45	.00781	.03830	73 639.	2 820.	361 350.	.95686	2 114 107.	28.709	2.572
50	.01002	.04890	70 819.	3 463.	345 760.	.94366	1 752 757.	24.750	2.593
55	.01350	.06540	67 356.	4 405.	326 280.	.92097	1 406 997.	20.889	2.616
60	.02005	.09570	62 951.	6 024.	300 493.	.88204	1 080 717.	17.168	2.633
65	.03121	.14530	56 926.	8 271.	265 047.	.81622	780 224.	13.706	2.632
70	.05166	.22970	48 655.	11 176.	216 336.	.58007[c]	515 177.	10.588	2.590
75	.12541	. .	37 479.	37 479.	298 841.	. .	298 841.	7.974	7.974

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

Life tables, Western province, 1979

Age	M(X,N)	Q(X,N)	l(X)	D(X,N)	L(X,N)	S(X,N)	T(X)	E(X)	A(X,N)
0	.11269	.10500	100 000.	10 500.	93 175.	.87524[a]	5 479 152.	54.792	0.350
1	.01491	.05740	89 500.	5 137.	344 443.	.94817[b]	5 385 977.	60.179	1.361
5	.00663	.03260	84 363.	2 750.	414 938.	.97482	5 041 534.	59.760	2.500
10	.00353	.01750	81 612.	1 428.	404 492.	.98157	4 626 596.	56.690	2.500
15	.00398	.01970	80 184.	1 580.	397 037.	.97910	4 222 104.	52.655	2.541
20	.00447	.02210	78 605.	1 737.	388 738.	.97690	3 825 068.	48.662	2.533
25	.00488	.02410	76 867.	1 853.	379 758.	.97476	3 436 330.	44.705	2.528
30	.00537	.02650	75 015.	1 988.	370 175.	.97186	3 056 572.	40.746	2.535
35	.00609	.03000	73 027.	2 191.	359 758.	.96764	2 686 397.	36.786	2.546
40	.00710	.03490	70 836.	2 472.	348 118.	.96266	2 326 639.	32.845	2.547
45	.00820	.04020	68 364.	2 748.	335 119.	.95512	1 978 521.	28.941	2.561
50	.01035	.05050	65 616.	3 314.	320 079.	.94230	1 643 403.	25.046	2.586
55	.01372	.06640	62 302.	4 137.	301 610.	.92089	1 323 324.	21.240	2.607
60	.01981	.09460	58 165.	5 502.	277 751.	.88445	1 021 714.	17.566	2.624
65	.03027	.14120	52 663.	7 436.	245 657.	.82326	743 963.	14.127	2.625
70	.04895	.21890	45 227.	9 900.	202 240.	.59414[c]	498 306.	11.018	2.586
75	.11932	. .	35 327.	35 327.	296 066.	. .	296 066.	8.381	8.381

[a] Value given is for survivorship of 5 cohorts of birth to age group 0-4 = L(0,5)/500 000.

[b] Value given is for S(0,5) = L(5,5)/L(0,5).

[c] Value given is S(70+,5) = T(75)/T(70).

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IV. THE PROFILE OF MORTALITY AND ITS DETERMINANTS IN SENEGAL, 1960-1980

P. Cantrelle, I. L. Diop,** M. Garenne,* M. Gueye** and A. Sadio***

Introduction

The purpose of this case study is to collect and analyse data on the profile of mortality and its determinants in Senegal over the two decades following independence (4 April 1960). This is a new page in the history of Senegal, but any comparison with prior periods is impossible, since there are virtually no data on mortality during the colonial period, except in Dakar and Saint-Louis.

The study involves the national level as well as the regional level. In each case an attempt is made to extract what is known of mortality trends and determinants, and in particular those of infant and child mortality, an age group that represents more than one half of total deaths and nearly two thirds in rural areas.

Senegal is one of the few countries of tropical Africa to have good demographic data and in-depth studies, making the analysis of determinants possible. This country exhibits the features of numerous tropical countries with low income, but it also has certain distinctive traits: in particular, an exceptional infant-child mortality pattern and a high concentration of child deaths during the rainy season. During the 1960s Senegal was also a pioneer in certain tropical health programmes: campaigns against malaria, mass vaccinations against measles, and the establishment of regional hospitals and dispensaries. An attempt is made to assess these activities in relation to mortality.

A. Background on Senegal***

The physical environment

Senegal is situated between 14°6′ and 18° north latitude, and 11°30′ and 17° west longitude. It lies in the north-western portion of the African continent, where it is marked by a point jutting out into the Atlantic Ocean. The terrain, on the whole, is flat and monotonous, except in the south-east, where a few elevations can be observed, the last foothills of the Fouta Djallon massif. The country is watered by several rivers, the most important of which are the Senegal, the Gambia in its upper reaches, and the Casamance.

The climate is tropical, marked by two clear-cut seasons: (*a*) the rainy (or winter) season, which is hot and humid and usually lasts from June to October, though this duration varies, depending on the region, from five months in the southern areas to no more than three months in the north; and (*b*) the dry season, which lasts the rest of the year. It is characterized by milder temperatures from November/December to February/March, particularly along the north coast. Precipitation diminishes as one goes from south to north, while temperatures become gradually lower as one moves from the interior towards the coast.

Since 1960 Senegal has been experiencing a drought cycle characterized by the alternation of years of medium rainfall and years of very low rainfall. Among the latter, the most pronounced were 1968, 1970, 1972, 1973, 1976, 1977 and 1980. These fluctuations are superimposed upon a decrease in mean precipitation over the entire country from 1960 to today.

These two phenomena have had extremely negative effects on the ecology of the country, including impoverishment of the vegetative cover and lowering of the water-table, as well as on the economic and social situation, including a decrease in agricultural production and an aggravation of the water problem.

The vegetation consists of thorn-bush steppe in the Sahelina portion of the country, wooded savannah in the Sine-Saloum region, and forests in Casamance and Sénégal Oriental. The soil is sandy and poor in the central and northern parts of the country, except in the flood-plain of the river and along the coast from Saint-Louis to Dakar. In Casamance and Sénégal Oriental, on the other hand, it is of the tropical ferruginous or argillaceous type and relatively richer.

Administrative and ecological regions

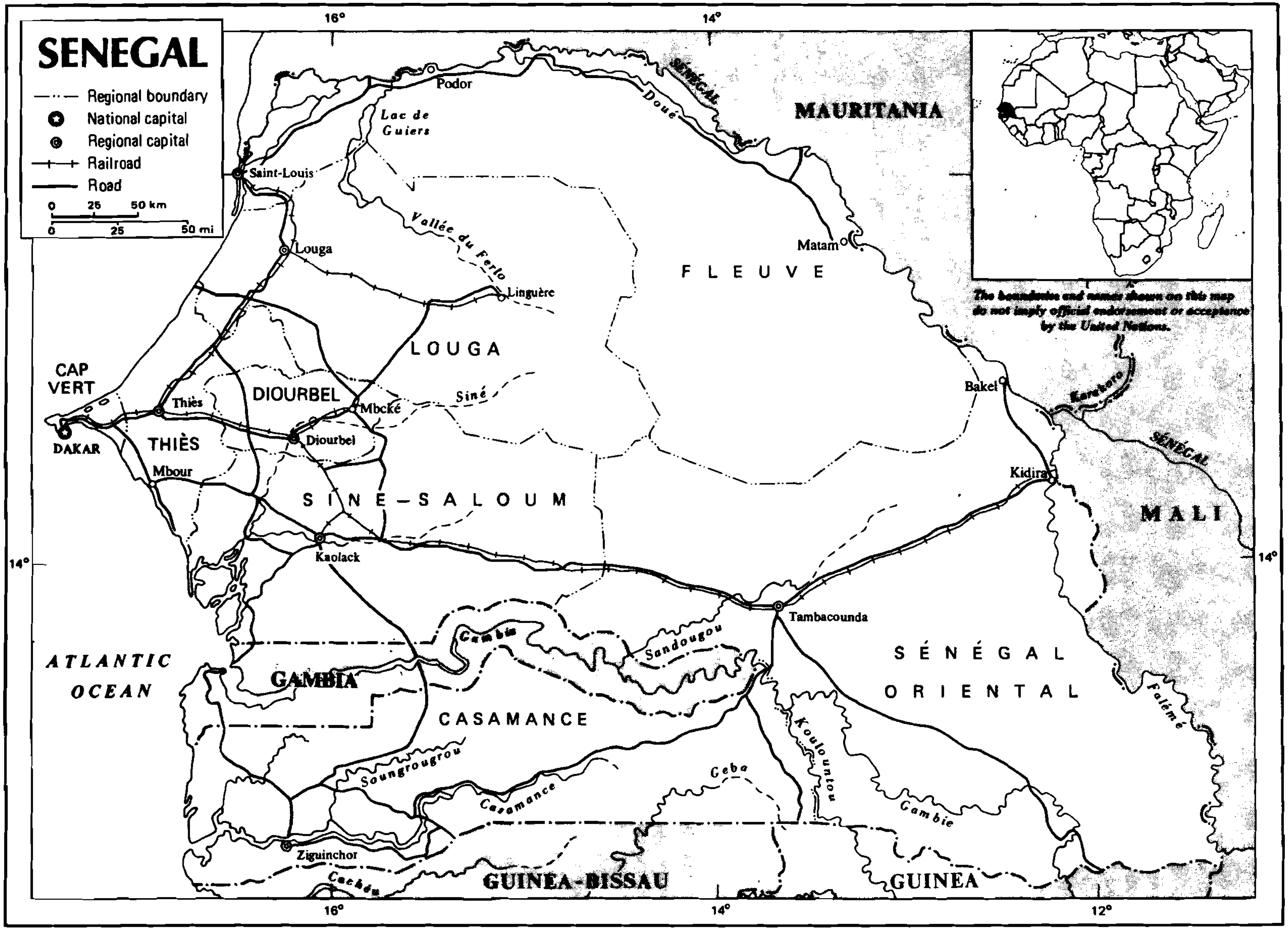
The country is divided into eight administrative regions (seven regions until 1976, after which Diourbel and Louga became separated), which can be grouped according to six ecological regions (see map 8).

Cap Vert. This is the smallest region in Senegal, but it is by far the most densely populated, economically the most developed and the most urbanized. It essentially corresponds to the city of Dakar and its suburbs.

Casamance. This is the most humid southern region. It is devoted to the growing of rice and cotton as well as fruit production. But dampness and the presence of numerous backwaters and flood plains are both a boon to the farm economy and a handicap from the standpoint of health. It is also slightly urbanized and moderately populated.

* Office de la Recherche Scientifique et Technique Outre-mer, Dakar.
** Direction de la Statistique, Ministère de l'Economie et des Finances, Dakar.
*** Prepared by I. L. Diop.

Map 8. Administrative regions of Senegal



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Louga and *Diourbel*. These are two typically Sahelian regions. The first is characterized by pastoral pursuits; the second, very small in area, is part of the peanut basin. Here, more than anywhere else, the water problem is acute.

Le Fleuve. Owing to the presence of the river, this region is primarily agricultural (in the valley) and pastoral (in the silvo-pastoral zone). But its population has remained very sparse, especially in the very dry wooded grassland area. The building of dams on the river will enable the region to play an outstanding role in national development.

Sine-Saloum and the *Thiès* region. This is the heart of the peanut-growing basin. After Cap Vert, these are also the most economically developed and most urbanized regions. The water problem is also present, but in a less crucial way than in the Louga region. In addition, the land along the coast suffers from a high degree of salinity.

Sénégal Oriental. A veritable pioneer land, with little population and little development. The depth of the aquifer (an average of 60 metres underground) and the presence of foci of onchocerciasis are two of the main problems of this region. Nevertheless, Sénégal Oriental has enormous irrigation-farming and mining potential.

A look at the economic situation

Immediately after independence, Senegal's economy was characterized by its dualism, its lack of integration and the existence of numerous disparities. With a view to improving the standard of living of its population more rapidly and to guaranteeing the harmonious development of the country as a whole, the Government opted in favour of a policy of economic and social planning.

However, the first 20 years of planning have not been sufficient to bring about any fundamental change in the structure of the Senegalese economy. It is still dominated by ground-nut monoculture, despite the efforts to diversify agricultural production and the spectacular expansion of industry. A rapidly developing but relatively unmonetarized traditional sector still exists side by side with a relatively highly developed modern sector.

During these two decades economic growth has been relatively slow. From 1960 to 1980 the gross domestic product (GDP), at constant prices (1971), grew at an average yearly rate of 2.2 per cent. This growth was sustained chiefly by the secondary production sector, which advanced at the rate of 3.3 per cent during that period. Three stages can be distinguished in the evolution of the GDP (see table 66):

(*a*) From 1960 to 1965: rapid growth of the GDP (3.9 per cent);

(*b*) From 1965 to 1975: slower growth (2.3 per cent);

(*c*) From 1975 to 1980: growth virtually at a standstill (0.2 per cent).

This unfavourable growth profile results from the conjuncture of a number of phenomena, the most important being:

(*a*) The cumulative effects of the drought and the continual rise in oil prices since 1972;

(*b*) Decreased ground-nut production, combined with the drop in world ground-nut prices;

(*c*) Lastly, the stagnation of the peanut oil factories, resulting in an appreciable reduction in investments, accompanied by an exodus of capital.

The structure of the GDP showed little change during this period. The share of primary industry remained more or less constant at approximately 30 per cent, except for the drought years. The secondary production sector advanced from 21 per cent in 1960 to 26 per cent in 1980, while the tertiary sector dropped from 50 to 46 per cent over the same period. These developments are the result of contradictory trends: a relative decline in agriculture and a considerable increase in fishing; an advancement of import-substitution industries, but a falling-off of peanut oil factories and mining industries (phosphate); and finally, a decrease in the services connected with the marketing of ground-nuts.

Senegal has thus witnessed only a slight restructuring of its economy, owing in large part to the difficulties of the ground-nut business and to the relative decline of phosphates, the country's two traditional exports. Senegal suffers from a chronic balance-of-trade deficit, aggravated by the drop in the prices of its export products on the world market and the rise in petroleum prices.

Per capita income has shown virtually no increase since 1960: approximately 45,000 CFA francs ($US 165) at constant 1971 prices. This mean value hides important regional disparities: the average income in Dakar is approximately six times as great as that in the rural areas; it would appear, however, that these disparities are attenuating.

TABLE 66. PROFILE OF THE STRUCTURE OF GDP BY SECTOR, SENEGAL, 1960 TO 1980

	Value in billions of CFA francs (in constant 1971 francs)					Growth rate (percentage)				
Sector	*1960*	*1965*	*1970*	*1975*	*1980*	*1960-1965*	*1965-1970*	*1970-1975*	*1975-1980*	*1960-1980*
Primary industry	47.2	58.7	62.0	72.3	69.0	4.5	1.1	3.1	-0.1	1.9
Secondary production	33.8	43.2	53.1	63.8	64.0	5.0	4.2	3.7	0.1	3.3
Tertiary (services) sector	80.1	93.0	102.8	108.5	113.5	3.0	2.0	1.1	0.9	1.8
Combined (GDP)	161.1	194.9	217.9	244.6	246.5	3.9	2.3	2.3	0.2	2.2

Source: Senegal, Direction de la Statistique, Dakar.

Demographic situation

Senegal is a West African country with a moderate size in terms of both population and area. It covers 196,722 square kilometres and had a population of 5.1 million inhabitants as of the April 1976 census. The population density (26 inhabitants per square kilometre) is also moderate.

The population is characterized by a youthful structure: 53 per cent of the population is less than 20 years of age, while people aged 60 and over represent only 6 per cent of the total. There has been very little change in this structure over the past 20 years. A slight increase has been noted, however, in the percentage of young people; this phenomenon might be explained in terms of the improvement in the quality of demographic data as well as of the decline in mortality among the young.

The sex distribution is very well balanced (98 men to every 100 women) and has not changed over the past two decades.

The population of Senegal is also characterized by intense, early nuptiality, especially among women. This may be linked with the predominance of the Muslim religion, which is that of over 80 per cent of all Senegalese.

On the whole, the population still has a relatively low literacy level: 80 per cent of the population aged 6 and over were illiterate in 1976. However, appreciable progress has been made in the area of education since the country gained its national sovereignty.

The population includes six ethnic groups: Wolof, Lebu, Fulani (Peuls), Tukulor, Serer, Dyola, Malinke and Sarakole. However, ethnic mixing from very early times has tended to blur these traditional distinctions. In 1976 the population of Senegal included some 300,000 foreigners, residing primarily in Cap Vert and in the peripheral regions (Casamance, Fleuve and Sénégal Oriental). The latter came mainly from bordering countries (Republic of Guinea, Guinea-Bissau, Mauritania, Mali and the Gambia).

As regards the natural increase of the population, the results of the Enquête Sénégalaise sur la Fécondité (ESF) (Senegal Fertility Survey) showed that the level of fertility was very high: the final mean number of offspring was 7.2 children per mother who had completed child-bearing.

Senegal is a country of large migration flows, both internal and international. The first of these phenomena results in very rapid urban growth. The population is concentrated in the western part of the country, the north and east being low-population zones. Though it is not known with any great precision, Senegalese emigration is very rapid. Emigrants come especially from the regions where climatic conditions are the most difficult (Fleuve, Sénégal Oriental, Louga and Diourbel).

The 1976 general population census was the first to be conducted in Senegal since independence. The demographic growth rate is estimated at 2.2 per cent between 1960 and 1965, increasing to 2.6 per cent between 1975 and 1979. The regional distribution is provided by two sample surveys (1960-1961 and 1970-1971) as well as by the 1976 census and the Senegal Fertility Survey, 1978. These regional distributions are more or less compatible and show a rapid increase for Cap Vert, a decrease for Sine-Saloum and Casamance, and no change for the other regions (see table 67). On this basis it is possible to make a reasonable estimate of the population of Senegal according to date and region (see table 68).

Table 69 presents estimates of the birth rate according to region during the period 1960-1980. It would seem that there has been an increase in fertility in Senegal over the past 20 years, and the most reliable estimate (that of the Senegal Fertility Survey) gives a birth rate of 47 per 1,000 with negligible regional differences.

TABLE 67. POPULATION DISTRIBUTION BY REGION, SENEGAL, ACCORDING TO VARIOUS DATA SOURCES, 1960-1978

Data source	*Senegal*	*Cap Vert*	*Casamance*	*Diourbel and Louga*	*Fleuve*	*Sénégal Oriental*	*Sine-Saloum*	*Thiès*
1960-1961 survey	100.0	14.3	17.0	16.2	11.1	4.9	23.4	13.2
1970-1971 survey	100.0	17.7	15.6	16.1	9.8	6.2	20.6	14.1
1976 Census	100.0	19.4	14.5	16.6	10.4	5.6	19.8	13.7
1978 ESF[a]	100.8	18.3	14.2	17.7	9.5	6.1	20.7	13.6

Sources: For 1960-1961, L. Verrière, "La population du Sénégal", thèse pour le doctorat ès Sciences Economiques, Université de Dakar, 1965, p. 31; for 1970-1971, Senegal, Direction de la Statistique, 1970-1971, unpublished; for 1976, Senegal, Direction de la Statistique, *1976 Census of Senegal*, analyse des résultats nationaux, Dakar; for 1978, Senegal, Direction de la Statistique, *Enquête Sénégalaise sur la fécondité*, 1978, Dakar.

[a] Enquête Sénégalaise sur la Fécondité.

B. DEVELOPMENT OF HEALTH SERVICES*

Modern health services constitute an important dimension in the sanitary environment of a country. To be sure, traditional medicine, too, plays a role in the state of health of the population, but improvements in the health level of a country generally come with the development of modern health services. In addition, there are virtually no data on the evolution of traditional medicine, whereas every year since 1960 the Senegalese Ministry of Health has been providing statistical series on its services.

*Prepared by P. Cantrelle. Unless otherwise noted, the cited data are to be found in the annual report, *Statistique Sanitaires*, published by the Ministère de la Santé.

TABLE 68. SENEGAL POPULATION ESTIMATES, ACCORDING TO REGION, 1955-1981
(in thousands)

Year	*Senegal*	*Cap Vert*	*Casamance*	*Diourbel and Louga*	*Fleuve*	*Sénégal Oriental*	*Sine-Saloum*	*Thiès*
1955	3 065	386	543	497	359	132	760	392
1956	3 133	404	551	508	363	138	768	401
1957	3 206	426	558	519	369	144	776	414
1958	3 281	446	568	532	374	151	787	427
1959	3 357	470	574	544	376	161	796	440
1960	3 435	491	584	556	381	168	804	453
1961	3 519	514	595	570	387	176	816	468
1962	3 604	541	602	584	389	189	825	483
1963	3 692	565	613	598	395	196	834	498
1964	3 781	594	620	613	397	208	843	514
1965	3 873	620	631	627	403	217	852	531
1966	3 967	651	639	643	405	230	861	547
1967	4 068	679	651	659	411	240	871	565
1968	4 171	713	659	676	417	250	880	584
1969	4 276	744	671	693	423	261	889	599
1970	4 385	776	684	706	430	272	903	618
1971	4 498	810	693	724	445	274	922	630
1972	4 615	845	701	748	452	277	937	641
1973	4 735	876	713	772	478	279	956	658
1974	4 857	913	724	797	485	282	976	670
1975	4 983	952	733	822	513	284	992	688
1976	5 113	985	737	842	528	286	1 008	699
1977	5 245	1 033	750	876	551	288	1 033	713
1978	5 387	1 077	760	905	571	291	1 050	733
1979	5 532	1 117	774	929	592	293	1 073	747
1980	5 687	1 166	785	961	614	296	1 098	762
1981	5 846	1 216	795	994	637	398	1 117	783

Source: Senegal, Direction de la Statistique, *1976 Census of Senegal*, analyse des résultats nationaux, Dakar, 1979, p.132; and estimates in 1980 and 1981. The distribution according to region is assumed to have progressed in a regular fashion from 1960 to 1970, from 1970 to 1976 and from 1976 to 1980.

TABLE 69. ESTIMATES OF BIRTH RATES (PER 1,000 POPULATION), SENEGAL, BY REGION, FROM VARIOUS SURVEYS, 1960-1979

Survey	*Senegal*	*Cap Vert*	*Casamance*	*Diourbel and Louga*	*Fleuve*	*Sénégal Oriental*	*Sine-Saloum*	*Thiès*
1960-1961	43	45	48	42	46	30	41	44
1970-1971	46	42	37	49	37	39	56	49
1978-1979	47	46	43	48	46	48	47	49

Sources: For 1960-1961, L. Verrière, "La population du Sénégal", thèse pour le doctorat ès Sciences Economiques, Université de Dakar, 1965, p.141; for 1970-1971, *Enquête Démographique Nationale*, p. 6; and for 1978-1979, Enquête Sénégalaise sur la Fécondité, unpublished.

The health infrastructure

Several different types of health facilities developed considerably during the period 1960-1980.

Hospitals. The facility is headed by a physician, includes several hospital wards and is usually located in the administrative capital of the region. The Cap Vert hospitals actually serve as national hospitals; they include most of the major divisions of modern hospitals. In 1960 there were no more than five hospitals in Senegal: three in Dakar, one in Saint-Louis and the last one in Kaolack (Sine-Saloum). There are now hospitals in the majority of the regional seats: Ziguinchor (Casamance), Diourbel and Thiès. In addition, the Dakar and Saint-Louis hospitals are now each backed up by outlying hospitals in the Senegal River valley, thus bringing the number of hospitals in operation in 1980 to 12.

Health centres. This type of facility is headed by a physician (or sometimes by a state-registered nurse, in the absence of a physician), and comprises a number of hospital beds. There is one in each departmental seat, so that their number remained practically unchanged during the period (34 in 1960, 35 in 1979).

*Health station or dispensary.** This is a unit headed by a nurse; it does not include any in-patient beds. These stations are generally located in the principal towns or in the seats of rural communities. Their number has increased fairly regularly and similarly in all the regions, more than doubling during the period: 201 in 1960, 469 in 1979. The majority of these entities are public, although the percentage of private dispensaries has risen

* The designation "health station" (*poste de santé*) appeared as of 1970 and replaced the term "dispensary" (*dispensaire*).

from 13 to 20 per cent of the total; this rise is due primarily to the increase in private dispensaries in Cap Vert (which constituted 35 per cent of all dispensaries in 1979).

Maternity clinics. Until 1977 these were located mainly in urban areas. Their number has increased steadily in all the regions, but especially in Cap Vert, rising from 39 in 1960 to 75 in 1977. Starting in 1978, numerous rural maternity clinics were created within the framework of the development of primary health care. In 1979 there were 76 in Sine-Saloum, 42 in Diourbel and Louga, 30 in Thiès and 27 in Casamance, totalling 189 for Senegal. These rural maternity clinics are generally rudimentary buildings equipped with a few beds and run by a nurse or a midwife.

MCW or MCH centres. Maternal and child welfare (MCW) or maternal and child health (MCH) centres are devoted basically to prevention: prenatal and postnatal supervision, nutrition and health education. They tended to diminish between 1967 and 1979, except in Sine-Saloum, where their number increased from 9 to 10.

In conclusion, the health infrastructure did develop in Senegal between 1960 and 1980, but it barely kept up with demographic advances. Thus, the number of hospital or health-centre beds per 1,000 inhabitants actually decreased. Only the considerable increment in the number of rural maternity clinics starting in 1978 and the setting-up of hospitals in the regional seats can be considered outstanding developments; they relate primarily to the end of the period under study.

Medical staff

While the infrastructure barely kept abreast of demographic advances, medical personnel, on the contrary, increased more rapidly than the population, and this may have had an impact on the health level of the population. According to statistics of the World Health Organization, the medical density (number of doctors of all categories, including military physicians, students in training, private doctors and researchers, per N inhabitants) rose from 1 per 24,000 in 1961 to 1 per 16,000 in 1977. The same is true of nurses belonging to the public sector (21 per 10,000 in 1961 to 45 per 10,000 in 1980) and midwives coming under the public sector (0.7 per 1,000 live births in 1960; 1.5 per 1,000 live births in 1980).

Health budget

The health budgets (estimated expenditures) published in the annual reports indicate that the portion of the national budget represented by the public health budget decreased from the mid-1960s, when it was over 9 per cent, to approximately 6 per cent in 1978. There was a relative increase in personnel, the share of equipment diminished and the share of the budget earmarked for medication remained more or less constant at 12 per cent. In any event, the Ministry of Health devoted a larger portion of its budget to staff (64 per cent) than the national mean (approximately 50 per cent). The majority of the investments and expenditures relating to equipment and drugs were connected with the hospitals, chiefly those of the capital.

Expenditures on medications, on the other hand, increased during the period. Malonga (1981) estimates this expenditure at 150 CFA francs per capita in 1965 and 400 CFA francs per capita 10 years later, which amounts to an increase that was greater than the inflation. The increase was related chiefly to private household consumption, which reflected an increase in the demand for drugs. According to customs statistics, the share of drug expenses provided by the public sector diminished greatly: from 60 per cent in 1964, it was down to 25 per cent in 1978.

Malaria control

Following the failure of pilot campaigns for wiping out malaria in the savannah zone, the Service de la Lutte Anti-Palustre (SLAP), or Malaria Control Department, starting in 1968, organized a preventive campaign for children aged from 0 to 14 years. This campaign involved the distribution of weekly doses of chloroquine (10 milligrams per kilogram of body weight) to children from 0 to 14 years of age throughout the entire rainy season. The Ministry of Rural Development initially supplied 40 million tablets. These were transported by the Malaria Control Department into each rural community. Each family head received a number of tablets corresponding to the needs of his children by way of an advance at the beginning of the winter season. The family head paid for this at the time of the harvest, along with other advances made by the co-operatives. The price was 1 CFA franc per tablet (approximately $US 0.004), which equalled the cost in Dakar (transportation costs were borne by the Malaria Control Department). The campaign showed rapid success, but ran out of steam because of the inability to provide for self-financing after 1975; it was apparently discontinued in 1978. According to studies made by the Malaria Control Department, in 1968 one third of the children received the prescribed dose. In one third of the cases the tablets were basically used as preventive medication; in one third of the cases, they were used rather for therapeutic purposes; and in one third, the adults themselves used the tablets. The number of persons seeking medical assistance for malaria did in fact diminish after 1968 as compared with the years 1963-1968. What remains is a sort of plateau, with marked annual variations, which means a relative decline in malaria, considering the population increase. Other factors of the drop in mortality due to malaria are studied in detail below. This decline in the number of persons seeking medical attention for malaria in the units headed by a physician (these being the units with the best diagnosis) is concentrated among children aged 0 to 14 years: the number of individuals seeking medical assistance aged from 0 to 14 years dropped 37 per cent between 1963-1967 and 1973-1977, whereas the population increased 29 per cent during the period. The number of out-patients aged 15 years and over decreased only 3.4 per cent during the same period. This clearly shows that the campaign had a considerable effect on the malaria morbidity rate. If the effects of environmental factors were involved, the adult rate would also have been markedly affected. On the contrary, a sharp rise in the number of adult out-patients was observed in 1975, which was a year of heavy rains following the drought, whereas the number of children out-patients for that year was lower than average. In conclusion, the impact of the chloroquine treatment campaign on malaria morbidity was probably very great between 1968 and 1977; it essentially involved children from 0 to 14 years of age, for whom the campaign was intended; to a lesser extent, adults also benefitted from it.

Measles vaccination

It was approximately during the same period (1967) that massive vaccination against measles was started. The campaign was organized in two stages: (*a*) 1967 to 1969: initial stage, during which the aim was to vaccinate the entire population aged from 1 to 7 years; and (*b*) 1970 +: maintenance stage, in which the goal was to vaccinate the new cohorts and those individuals who had been missed during the previous campaigns.

During the initial phase 682,901 children were vaccinated, representing 74.8 per cent of the estimated 1-to-7-year-old population in 1968. This amounted to fairly good coverage, assuming that no children were vaccinated twice and that there were no overflows into other age groups (the Sine-Saloum survey shows that both these conditions did exist). Measles vaccination seems to have been continued on a regular basis after 1970, and the number of vaccinations reflects an average of 82.5 per cent of the children born and surviving up to 1 year of age (assuming an infant mortality rate of 150 per 1,000). Here again, coverage appears satisfactory. Nevertheless, the number of cases of measles declared in the hospitals or health stations increased, despite a decline between 1968 and 1970; the same is true of the number of deaths due to measles in the hospitals. This would imply that the quality of vaccination diminished during the maintenance stage. Measles vaccine is in fact highly unstable and highly temperature-sensitive: it must be kept at 4° C until used in order to be fully effective. What is more, it does not appear that vaccination covered the entire country: at Ngayokhème, there were no campaigns between 1968 and 1979, and the number of cases of measles rose after 1970, eventually reaching its pre-1966 equilibrium (date of the first campaign). To sum up, aside from the successful initial phase in 1967-1969, it does not appear that vaccinations against measles achieved the sought-after efficacy after 1970.

Hygiene

Outside of the large cities there do not appear to have been any major actions for improving hygiene. In the Ngayokhème survey area a number of very deep wells have been drilled recently (1979 and 1980), with Chinese co-operation; in all likelihood this will have an impact on public health, inasmuch as water is an important source of pollution. Nothing important seems to have happened in rural areas between 1960 and 1980, however.

In conclusion, several points relating to the development of health facilities in Senegal are important, and they may have had an impact on mortality between 1960 and 1980:

(*a*) An increase in medical and paramedical staff;

(*b*) Increased drug (i.e. medication) consumption;

(*c*) An anti-malaria campaign involving the distribution of chloroquine to children aged 0 to 14 years;

(*d*) A mass vaccination campaign against measles in the late 1960s.

Added to this is the further development of the urban hospital infrastructure. This list does not take in all the health actions conducted by the country since independence: in particular, one would have to add the various actions by the Service des Grandes Endemies (Major Endemic Diseases Service), such as the fight against leprosy, and sanitation efforts in various regions of the country. Since 1979, a primary health care system has been initiated and will probably have an impact on mortality in disadvantaged areas, in particular rural ones; and also, a considerable effort to improve the water supply has been under way for several years.

C. Mortality: levels and trends*

Data

Since independence Senegal has conducted several nation-wide demographic surveys. Included among them are: three traditional demographic surveys carried out, respectively, in the periods 1960-1961, 1970-1971 and 1978-1979; two specialized surveys, the first on fertility, in 1978, and the second on migrations, in 1979; and lastly, a general population census in 1976.

Aside from the census and the migration survey, all of these surveys provide information on mortality. The retrospective survey of 1960-1961 gives the deaths for the previous 12 months and asks Brass type of questions (live-born children/surviving children). The multi-round survey of 1970-1971 gives the deaths between the first and third rounds, spaced approximately a year apart. The same was true of the two rounds of the 1978-1979 survey. Finally, the Senegal Fertility Survey gives maternity and child survival histories.

The basic demographic studies have been only partially processed. Only provisional or partial results are available so far. The Senegal Fertility Survey is the only operation to have been processed completely.

The data emerging from these surveys are uneven in terms of value. The retrospective data of the 1960-1961 survey, for example, suffer greatly from underestimation, which has rendered them virtually unusable. Only the data on child survival could be used in conjunction with those derived from other sources. Having recourse to the technique of multi-round surveys improved data quality during the 1970-1971 and 1978-1979 surveys to a considerable extent.

Unlike the retrospective data, the levels of recording of events (births and deaths) between the first and last round are quite satisfactory on the whole. An analysis, using the method of Jean Bourgeois Pichat, showed that the levels of coverage obtained for all of Senegal, in 1970-1971 and in 1978-1979 alike, were close to 100 per cent, for births as well as for deaths (see table 70).

One finds, however, that coverage is better for births. This can probably be explained by the fact that a fertility

* Prepared by I. L. Diop, A. Sadio and M. Gueye.

TABLE 70. ESTIMATES OF BIRTH AND DEATH REGISTRATION COMPLETENESS OBSERVED BETWEEN THE FIRST AND LAST ROUNDS OF THE 1970-1971 AND 1978-1979 DEMOGRAPHIC SURVEYS
(*Percentage*)

	1970-1971 survey		*1978-1979 survey*	
	Births	*Deaths*	*Births*	*Deaths*
Urban area	97	89	93	92
Rural area	105	98	99	97
Country total	100	97	97	95

survey was coupled with each of these operations, and that this must have appreciably reduced birth omissions. In addition, the fact that these surveys were spread out over a period of more than 12 months, coupled with errors in estimating dates, may have led to events being taken into account that actually occurred outside of the reference period: this would probably explain the rates higher than 100 per cent.

With respect to deaths, it is unlikely that there were many omissions beyond 1 year of age, in view of the fact that the task set was to follow the fate of the individuals enrolled at the time of the first round. It seems likely that, beyond one year, deaths may have been overestimated, since deaths occurring outside of the reference period may have been mistakenly included. On the other hand, owing to the length of the period which elapsed between two rounds, systematic omissions must have occurred owing to the deaths of children aged less than 1 year, when births were closely followed by death or when the children who died were born of mothers who died during childbirth. It also appears that errors in estimating ages caused many infant deaths to be recorded in the 1-to-4-year-old group.

As far as age distributions are concerned, these two surveys also yielded satisfactory results in spite of the uncertainty involved in age determination. The pyramids obtained have fairly regular profiles, unlike the case of the 1960 survey. The United Nations Combined Index shows a moderate value for these two surveys and seems to indicate a gradual improvement of age data (table 71).

TABLE 71. INDICATORS OF THE QUALITY OF AGE DATA, 1960-1979

Survey	*Sex ratio*	*Whipple index (F)*	*Meyers index*	*U.N.C.I.*[a]
1960-1961 demographic survey	.97	122.5	13.2	64.3
1970-1971 demographic survey	.97	100.0	12.8	42.3
1976 Census	.98	168.7	26.6	40.4
1978-1979 demographic survey	.98	104.6	3.7	39.9

[a] U.N.C.I. = United Nations Combined Index.

The data used in this chapter have therefore been taken from the three basic demographic surveys and the Senegal Fertility Survey. All these data can be considered of fairly good quality, which is exceptional for tropical Africa. Reservations concerning the reliability of the data will be expressed as the analysis of the results proceeds.

Mortality levels and trends

For estimating mortality levels and trends on the national scale two categories of data were used: (*a*) those relating to the reference years (1960, 1970 and 1978); and (*b*) for children under 5 years of age, the retrospective series of the Senegal Fertility Survey for the period 1963-1977. For the first category we have presented, each time, the uncorrected data accompanied by corresponding corrected estimates (see table 72).

TABLE 72. EVOLUTION OF THE PRINCIPAL INDICATORS OF MORTALITY, SENEGAL, 1960-1978

	Death rate (per 1,000 population)		*Life expectancy at birth (in years)*	
Year	*Uncorrected*	*Corrected*	*Uncorrected*	*Corrected*
1960	16.7	26.6[a]	. .	38.1[a]
1970	21.1	22.1[b]	43.3	42.6[b]
1978	17.6	19.3[b]	48.2	47.3[b]

[a] Corrected rates as reported by Verrière (1965) for 1960.
[b] After correction of indices for the urban area using the rates obtained by application of J. Bourgeois Pichat's method to vital registration data.

The estimates presented in table 72 are relatively consistent. They all show that the Senegalese population has remained subject to high mortality despite the drop that appears to have occurred since independence. On the basis of these data, the crude death rate declined from a level of 26.6 in 1960 to 19.3 in 1978. At the same dates, expectation of life at birth was respectively of the order of 38 years and 47 years. During the period from 1960 to 1978, life expectancy thus increased 9 years, which represents a mean annual increase of 0.5 year.

However, these results must be viewed with the reservations mentioned earlier in connection with the uneven quality of the data. Nevertheless, the agreement between these estimates, made in accordance with different methods, leads one to believe that these data are fairly good and that the overall level was correctly captured, even though infant mortality was in all likelihood underestimated.

Furthermore, the declining trend shown by these data is confirmed by the results of the fertility study relating to the infant and child mortality series covering the period from 1963 to 1977. The index, ${}_5q_0$, declines appreciably, although with fluctuations (see table 73).

Mortality pattern

The mortality pattern in Senegal exhibits four characteristic features.

(*a*) On the whole, male mortality is higher than female mortality. Based on the results of the 1978-1979 survey, expectation of life at birth in 1978 was, based on uncorrected data, calculated at approximately 47 years for men and 49 years for women (see table 74), which represents a difference of 1.7 years. This excess male mortality is less marked among the young than at adult ages. Moreover, between the ages of 1 and 5 years and at certain fertile ages an inversion of the phenomenon is observed. In 1978 the mortality quotient between the ages of 1 and 4 years was 147 per 1,000 live births for

TABLE 73. PROBABILITIES OF DYING DURING INFANCY AND CHILDHOOD, 1963-1977, BASED ON THE 1978 SENEGAL FERTILITY SURVEY

(Uncorrected data)

Year	Probabilities of dying between ages: 0 and 1	1 and 5	0 and 5
1963	109	200	287
1964	121	249	340
1965	106	157	246
1966	108	205	291
1967	128	180	285
1968	110	168	260
1969	109	214	300
1970	141	159	278
1971	103	127	217
1972	119	173	271
1973	129	195	299
1974	102	174	258
1975	118	174	271
1976	100	114	203
1977	119	129	233

males and 152 for females (table 74). This slight predominance of female mortality (which does not appear, however, in the 1970 tables) is more pronounced in rural areas than in urban areas. Also, at age 15, the gap between the life expectancy of men and that of women is 2.6 years. This means that in adult ages, male mortality outweighs female mortality by far.

(*b*) Infant mortality was still very high in 1978. According to the results of the 1978-1979 survey, the infant mortality rate was approximately 94 in 1978. For the whole of Senegal (table 74) this value is probably too low. The relatively long interval separating the two rounds of the survey most certainly must have induced omissions of deaths of children aged less than 1 year and the transfer of deaths at age 0 to the 1-to-4-year-old group. Births followed by death, and also deaths of children of mothers who died following childbirth, must have systematically escaped observation. The use of the Brass method (child survival) gives an infant mortality rate of 156 per 1,000, which can be considered an upper limit (taking into consideration the fact that this method usually overestimates $_1q_0$). Adjustment using the tables (model 2.4, using the observed 8(5) and $_{15}q_{35}$) from the Organisation for Economic Co-operation and Development (OECD) yields an infant mortality of approximately 120. The retrospective data of the Senegal Fertility Survey indicate an infant mortality rate of approximately 118, which is fairly close to the estimate for the OECD tables.

TABLE 74. CHANGES IN MORTALITY INDICATORS, 1960-1978

Index and year		Corrected: Males	Females	Both sexes combined	Uncorrected: both sexes combined
Crude death rate (per 1,000 population)	1960	..	..	16.7	22.6
	1970	23.2	19.1	21.1	22.1
	1978	18.5	16.5	17.6	19.3
Probability of dying between ages (per 1,000 base population)					
0 and 1	1960	..	..	..	147.7
	1970	109.3	95.5	102.4	123.0
	1978	94.5	93.6	94.1	120.0
1 and 5	1960	..	..	..	253.5
	1970	214.9	182.8	199.2	206.4
	1978	147.0	151.7	149.4	149.3
0 and 5	1960	..	..	..	364.1
	1970	300.7	260.8	281.2	304.1
	1978	227.6	231.1	229.3	242.3
Life expectancy at birth (in years)	1960	..	..	..	38.1
	1970	42.2	45.2	43.8	42.6
	1978	47.3	49.0	48.2	47.3
Life expectancy at age 10 (in years)	1960	..	..	..	40.5
	1970	47.5	48.5	47.8	45.0
	1978	48.9	51.5	50.0	49.1

NOTE: See text for explanation of how these figures are calculated.

In view of all the above, one can say that the true value of the infant mortality rate lies somewhere between 120 and 150. It is thus very high.

(*c*) The third characteristic feature is that the probability of death between the first and fifth birthdays is greater than the probability of death between birth and the first birthday. In 1978 these indices were estimated respectively at 149.3 and 120.0 (table 74). The former is over 20 per cent greater than the latter. This higher level of mortality of the 1-to-4-year-old group is not peculiar to Senegal. It is also observed in a certain number of tropical or Mediterranean countries with high death rates, such as Egypt, and is reflected in the Coale-Demeny (1983) South model life table based upon Mediterranean countries.

The existence of this excess mortality between the ages of 1 and 5 years is probably due to poor weaning conditions, the slacking-off of care, malnutrition and greater exposure to disease vectors. Studies done by Cantrelle (1969) show that this excess mortality occurs between the ages of 7 months and 3 years. These studies yielded the following results:

Probability of dying between ages	Niakhar	Paos-Koto
	(per 1,000 base population)	
0 and 1	210	130
1 and 5	354	240

This phenomenon is indicative of a very special mortality pattern in young children. However, this additional mortality at ages 1 to 4 is sometimes accentuated because of errors relating to age at the time of death, resulting in the inclusion of deaths at age 0 in the 1-to-4-year-old group, owing to the lack of precision regarding age.

Deaths of infants and young children (0 to 4 years) thus represent an extremely high percentage of the total number of deaths: 58 per cent in 1978 (see table 75).

TABLE 75. DISTRIBUTION OF DEATHS BY AGE IN 1978
(*data from 1978-1979 demographic survey*)

Age	Senegal total		Rural areas		Urban areas	
	Number	Percentage	Number	Percentage	Number	Percentage
0 - 1	746	25.0	636	25.8	110	21.1
1 - 4	988	33.0	857	34.7	131	25.1
5+	1 254	42.0	974	39.5	280	53.8
TOTAL	2 988	100.0	2 467	100.0	521	100.0

Source: Enquête ménage, 1978-1979 (unpublished).

While infant mortality was largely underestimated in the different surveys, child mortality (1-5 years), on the other hand, seems to have been captured relatively accurately. The 1978-1979 survey gives a rate of 229.3 for Senegal as a whole. If this is corrected with J. Bourgeois Pichat's coefficient, one obtains a rate of 242.3 (see table 74). The Brass method also yields 242 (Senegal Fertility Survey preliminary analysis report, page 40). Similarly, the retrospective data of the Survey show a rate of 233 for the year 1977 (table 73).

(*d*) The fourth and last feature of mortality in Senegal is that, as compared with the standard tables, adolescent and adult mortality appears moderate. It exhibits no further peculiarities other than near-constant higher mortality for males.

To turn now to the evolution of mortality in the past, one observes that the recorded drop in mortality is due primarily to the decline of mortality in childhood (1-4 years), although infant mortality and adult mortality also diminished somewhat. For example, expectation of life at age 15 apparently went from 40.5 years in 1960 to 49.1 years in 1979, which amounts to a gain of 8.6 years over an 18-year period (table 74).

Finally, the evolution of the mortality pattern appears to exhibit the following special characteristics:

(i) Among the young, male mortality is declining more rapidly;

(ii) Among adults, female mortality is declining more rapidly.

Mortality in Dakar and Saint-Louis

Mortality in the cities of Dakar and Saint-Louis is distinctly lower than the national average, as shown by the following indicators. Infant mortality was of the order of 60 per 1,000 in Dakar and 75 per 1,000 in Saint-Louis for the period 1973-1980 (see tables 76 and 77). On the national level, the same index was in the neighbourhood of 110 to 150 per 1,000 for the same period. As for the child mortality quotient ($_4q_1$), its value was close to the $_1q_0$ value for Dakar, but it was clearly higher than this in Saint-Louis, where it was in the vicinity of 110 per 1,000. Lastly, expectation of life at birth was about 58 years in Dakar and 50 years in Saint-Louis, whereas the national mean was approximately 43 years.

These differences between the national mean and the urban areas, on the one hand, and between Dakar and Saint-Louis, on the other, might be explained by various factors, such as:

(*a*) Health infrastructures: one third of the hospitals were concentrated in the city of Dakar alone; what is more, 82 per cent of the physicians were located there, which amounted to an average, in 1976, of one physician per 3,147 inhabitants, as against one physician per 66,592 inhabitants for the rest of the country;

(*b*) The socio-cultural level: based on the results of the April 1976 census, the literacy level among the population of Dakar was 44 per cent, whereas the national average was only 20 per cent;

TABLE 76. MORTALITY INDICATORS IN DAKAR, BOTH SEXES COMBINED, 1973-1980

Year	Crude death rate (per 1,000 population)	Probability of dying between ages: 0 and 1	1 and 5	0 and 5	Life expectancy at birth	age 15
		(per 1,000 base population)			(in years)	
1973	10.8	57.8	74.8	128.3	55.2	49.2
1975	10.4	55.0	63.6	115.1	55.9	49.5
1976	10.8	64.1	65.1	125.0	55.4	49.5
1977	9.4	60.4	53.4	110.6	58.5	51.8
1978	9.3	58.2	57.2	112.1	58.6	52.0
1979	8.1	46.6	35.5	80.4	60.1	51.2
1980	8.8	60.3	43.5	101.2	59.5	52.1

Source: Vital registration (unpublished).

TABLE 77. MORTALITY INDICATORS IN SAINT-LOUIS, BOTH SEXES COMBINED, 1973-1980

Year	Crude death rate (per 1,000 population)	Probability of dying between ages 0 and 1	1 and 5	0 and 5	Life expectancy at birth	age 15
		(per 1,000 base population)			(in years)	
1973	20.8	79.2	146.8	214.4	44.1	43.4
1974	17.6	67.6	153.4	210.6	47.6	47.2
1975	14.5	66.3	115.6	174.2	52.8	50.1
1976	16.5	83.5	119.5	193.0	49.8	48.2
1977	14.7	79.1	97.6	169.0	42.4	49.4
1978	14.8	85.8	109.5	185.9	52.4	50.1
1979	13.4	83.0	80.8	157.1	54.1	50.2
1980	13.0	76.7	63.6	135.4	54.6	49.5

Source: Vital registration (unpublished).

(*c*) Living conditions: the higher quality of housing in the urban zone, better city sanitation systems, good quality of drinking water in cities—all these are factors that affect hygiene and consequently the morbidity and mortality of the population;

(*d*) Economic factors: higher income levels in the city constitute one of the factors that explain these differences. Indeed, in 1976 Dakar accounted for 83 per cent of the commercial establishments and 87 per cent of all non-agricultural jobs.

The mortality pattern is characterized by a 1-to-4-year-old quotient that is just as high as ${}_1q_0$ in Dakar and definitely higher in Saint-Louis.

This higher juvenile mortality is more marked in Saint-Louis, where the general mortality level is more elevated than in Dakar. Also, as for the country as a whole, the death rate is higher among men than among women.

The values of the above indicators undergo smaller yearly fluctuations than those observed in the Ngayokhème survey. However, the general trend is a downward one, although the extent of decline depends on both the age and the index considered. Although for infant mortality no clear-cut tendency seems to emerge, either in Saint-Louis or in Dakar, the child mortality quotient is on the decline in the cities. This is reflected in an increase in expectation of life at birth of 10 years in Saint-Louis and 4 years in Dakar between 1973 and 1980. It can thus be considered that, despite actual yearly variations ascribable in part to changes in the amount of rainfall and its consequences from one year to the next, mortality, generally speaking, is on the decline in Dakar and Saint-Louis.

Seasonal variations are also one of the characteristic features of urban mortality, as well as of mortality in Senegal in general. Peak death rates are observed during the hot, humid season: i.e., from July to October. They generally lag approximately a month behind precipitation peaks. The lowest rates are registered during the dry and relatively cool season, or, in other words, from November to May. The maximum monthly percentages of deaths are in the vicinity of 10 per cent, while the minimal average is 6 per cent. This divergence denotes the high concentration of deaths during or immediately following the rainy season. These differentials, however, are not so wide in Dakar as in Saint-Louis, in spite of the fact that the level of rainfall is higher in the former. Mortality appears to be more dependent upon climatic factors (water and drought level) in Saint-Louis than in Dakar.

Causes of death

The precision of the cause mentioned on death certificates depends on both the place where the death took place and the cause itself. In the case of deaths occurring in the health units (68 per cent of all cases in Dakar and 58 per cent in Saint-Louis for the entire period 1973 to 1980), the cause indicated is theoretically more precise, for in the majority of cases it was established on the basis of a doctor's diagnosis. The same is not true of deaths that took place in the home (32 per cent of all cases in Dakar and 42 per cent in Saint-Louis). Here, in theory, a public medico-legal officer is in charge of making a diagnosis for identifying the cause. Except in cases of violent death, it is in fact the relatives who report the apparent symptoms that resulted in death, and the doctor does not go beyond these declarations. This system leads to errors regarding the real cause. However, for certain readily identifiable diseases, such as measles or diarrhoea, these risks of error are not so great, even if the death occurs at home. Added to this imprecision are the cases of contributing causes, which have not been taken into account in this study, owing to the fact that they are not systematically recorded in all the health centres.

Despite these sources of imprecision, the recording of causes can be considered satisfactory, since, on the average, the cause is mentioned in over 80 per cent of all cases. Because the vast majority of deaths occur to children, the analysis considers the following age groups: less than 1 year, 1-4 years and 5-14 years (see tables 78 and 79).

Causes of death under age 1. The primary cause of death at this age is connected with congenital and perinatal diseases. For the period 1973 to 1980, on the average one quarter of the deaths in Dakar and one third in Saint-Louis were due to these causes. They involved boys and girls about equally. The percentages of deaths due to these causes varied over time between 19 and 30 per cent in Dakar and 23 and 48 per cent in Saint Louis. A priori, one might consider these causes as being independent of certain environmental factors, such as the amount of rainfall. Unlike the case of the Ngayokhème study, one finds, as far as registration data are concerned, that congenital causes are far more frequent than any other causes, such as malaria or diarrhoea. It is not that congenital and perinatal deaths are more com-

TABLE 78. PERCENTAGE OF TOTAL DEATHS DUE TO MAJOR CAUSES, BY SEX, CAUSE AND AGE, DAKAR, 1973-1980

Cause	Men	Women	Combined	Maximum[a]	Minimum[a]
	0 years				
Congenital disorders	24.8	24.2	24.6	30.2(1979)	19.4(1978)
Malnutrition and dehydration	6.5	6.2	6.4	8.2(1980)	4.0(1976)
Measles	9.3	10.2	9.7	14.8(1978)	5.1(1979)
Diarrhoeas	11.4	11.8	11.6	15.9(1975)	8.4(1978)
Broncho-pulmonary disorders	5.8	5.7	5.8	9.5(1974)	1.3(1979)
	1 to 4 years				
Measles	26.7	29.1	27.8	33.4(1977)	16.6(1975)
Malnutrition and dehydration	7.0	6.2	6.8	10.3(1980)	5.5(1973)
Diarrhoeas	11.9	12.6	12.2	14.8(1975)	9.6(1978)
Malaria	2.1	2.5	2.3	-	-
Broncho-pulmonary disorders	8.7	9.1	8.9	-	-
	5 to 14 years				
Malaria	3.7	4.9	4.2	7.8(1975)	1.4(1980)
Tetanus	7.1	5.1	6.2	-	-
Diarrhoeas	4.0	5.8	4.8	7.7(1974)	3.3(1977)
Measles	3.3	6.8	4.8	-	-
Broncho-pulmonary disorders	6.1	8.6	7.1	-	-

Source: Vital registration (unpublished).
[a] Years in parentheses are those in which the maximum or minimum percentage was recorded. Percentages do not sum to 100 because of the existence of other causes of death.

TABLE 79. PERCENTAGE OF TOTAL DEATHS DUE TO MAJOR CAUSES, BY SEX, CAUSE AND AGE, SAINT-LOUIS, 1973-1980

Cause	Men	Women	Combined	Maximum[a]	Minimum[a]
	0 years				
Congenital disorders	32.9	32.5	32.7	48.2(1975)	23.3(1979)
Malnutrition and dehydration	10.0	10.2	10.1	16.6(1973)	6.0(1980)
Measles	7.2	6.9	7.0	11.1(1974)	1.4(1975)
Diarrhoeas	6.0	4.8	5.4	8.0(1978)	3.8(1977)
Malaria	4.6	6.0	5.2	7.2(1980)	3.5(1978)
	1 to 4 years				
Measles	19.5	22.1	20.8	27.2(1974)	10.1(1973)
Malnutrition and dehydration	18.2	17.4	17.8	25.6(1973)	14.3(198)
Diarrhoeas	10.6	8.8	9.7	17.6(1973)	5.2(1980)
Malaria	9.6	9.3	9.4	13.5(1975)	3.7(1977)
Broncho-pulmonary disorders	4.1	3.0	3.6	3.8(1973)	-
	5 to 14 years				
Malaria	18.7	22.8	20.5	34.1(1980)	8.1(1977)
Tetanus	6.4	3.5	5.1	10.2(1980)	8.0(1978)
Diarrhoeas	5.7	3.8	4.8	6.8(1973)	7.1(1980)
Measles	4.5	8.8	6.4	9.2(1978)	2.3(1980)
Broncho-pulmonary disorders	4.8	1.8	3.4	5.3(1976)	-

Source: Vital registration (unpublished).
[a] Years in parentheses are those in which the maximum or minimum percentage was recorded. Percentages do not sum to 100 because of the existence of other causes of death.

mon in the cities, but that in Ngayokhème the relatives are often not able to identify such causes.

Intestinal diseases represent the second greatest cause of death in Dakar at age 0, with 12 per cent for the period 1973-1980. This percentage, however, varies to a considerable extent over time (see maximum and minimum figures in tables), while differences according to sex are slight. The incidence of deaths due to diarrhoeas at age 0 is lower in Saint-Louis (5.4 per cent) than in Dakar. In Saint-Louis, after congenital diseases, it is rather deaths due to malnutrition and dehydration that show the highest incidence (10 per cent). As we shall see from the other age groups, diarrhoea flared up especially in 1973 in Saint-Louis, a year of intense drought preceded by the still worse drought of 1972. Insufficient food production as a result of this drought cycle was probably the major reason.

Causes of death at age 1-4 years. Measles is still the chief cause at this age, in both Dakar and Saint-Louis. The percentage of deaths due to this disease is 28 per cent in Dakar and 21 per cent in Saint-Louis. Yearly variations in these percentages are very great (see maximum and minimum figures in tables), which indicates the importance of this pathological phenomenon. The major epidemic years were 1974 for Saint-Louis and 1977 for Dakar.

Diarrhoea ranks second, with a mean of 10 per cent, in Dakar. In Saint-Louis, however, diseases connected with malnutrition and with dehydration constitute the second most important cause, with a fairly high percentage: 26 per cent. As in the case of age 0, the highest incidence of deaths due to this cause was observed in 1973.

The incidence of broncho-pulmonary diseases is fairly high in Dakar (9 per cent), whereas it is far less so in Saint-Louis. On the other hand, malaria is a far more common cause in Saint-Louis (14 per cent) than in Dakar. As regards Saint-Louis, one observes that corresponding to the years of heavy rainfall (e.g. 1975) there are elevated percentages of deaths due to malaria, whereas drought years (e.g. 1977) are marked by much lower percentages. This phenomenon is not manifest in the case of Dakar, where the incidence of malaria is far lower.

Lastly, broncho-pulmonary diseases are fairly frequent causes at this age.

If one leaves out measles, the epidemic character of which has been pointed out, it would appear that the incidence of the major causes of infant mortality is tied up with the amount of rainfall, drought and their consequences as regards the availability of food, and perhaps also of purchasing power. These links are far more clearly visible in Saint-Louis.

Causes of death at ages 5-14 years. The frequency of deaths due to measles and diarrhoeal diseases declines at these ages, giving way to malaria, which increases greatly, especially in Saint-Louis. The percentage of deaths due to this cause averages 21 per cent in Saint-Louis, while it runs about 4 per cent in Dakar. Deaths due to tetanus are also quite frequent at these ages, as are broncho-pulmonary diseases.

The impact of the amount of rainfall on causes of death such as malaria, on diseases connected with malnutrition and dehydration and on the general level and pattern of mortality has been outlined in the foregoing paragraphs. In analysing the results of the Ngayokhème survey, one notes that all the high-mortality years are also years with a large amount of rainfall. The impact of the amount of rainfall on the mortality level is perhaps greater in rural areas, where sanitary and health infrastructures as well as medical staff are much more inadequate than in the towns. However, in urban areas, one also finds that years of drought are also years of high mortality when they are preceded by droughts. Thus, to the malaria and diarrhoea that are rampant during wet seasons are added nutritional deficiencies linked with inadequate food production during the previous year. Such nutritional deficiencies are particularly deadly at the age of 1 to 4 years. In this way one might explain the high incidence of diseases connected with malnutrition in 1973, as well as the high rate of mortality recorded during those years, especially in Saint-Louis. This is tantamount to saying, also, that the amount of rainfall does not have a mechanical impact on mortality, but rather acts through more or less direct factors such as certain pathological phenomena, or indirect factors such as food, income or sanitary conditions.

This very succinct view of mortality in Dakar and Saint-Louis permits a number of conclusions:

(*a*) Owing to the more advanced health infrastructures that exist in these two cities as well as the cultural and socio-economic level of their populations, mortality in Dakar and Saint-Louis is lower than the national average;

(*b*) This study confirms the pattern of mortality at young ages observed in all the surveys carried out in Senegal: namely, high infant and child mortality quotients. But this high death rate becomes less marked and in fact disappears as the general level of mortality drops;

(*c*) In spite of the year-to-year fluctuations connected essentially with precipitation levels, the trend is for mortality to diminish. This tendency is more marked between the ages of 1 and 4 years, while the infant mortality rate has shown virtually no change;

(*d*) Perinatal diseases, and in particular congenital abnormalities, are still the number one cause of death at age 0; the other common causes at that age are connected with nutrition and the environment. Measles, intestinal diseases, malnutrition and malaria are the causes frequently observed from age 1 to 4; and malaria is the principal cause from 5 to 14 years of age. With the exception of congenital abnormalities, which are a threat especially during the very first days after birth, and measles, characterized by its epidemicity, the chief causes of death at age 0 years and especially at age 1 to 4 years are tied up with climatic factors and their consequences.

Conclusion

Mortality is still high in Senegal, despite a drop that has been observed since independence. This decline in mortality is due mainly to a decrease in child mortality and, to a lesser extent, to the lowering of the death rate in adults.

The reduction in mortality cannot be attributed solely to progress in the area of health facilities, inasmuch as a large portion of the population has not yet been reached by such services. This downward trend also results from the improvement in living standards (income, hygiene, educational level etc.)

The high mortality rate observed in the past from ages 1 to 4 years is beginning to decline in urban areas. Otherwise, mortality is still dependent on the physical environment and on transitory weather factors. This dependence results from the relative lack of development of health infrastructures, which in reality benefit only an urban minority, and from the slow rate of improvement of the standard of living and the level of education of the population.

D. Determinants of mortality in infancy and childhood*

This study of the factors determining mortality ought to have included numerous parameters that are not measurable or whose impact on mortality cannot be measured. This is the case, in particular, with the condition of and changes in the epidemiologic environment and with the detailed impact of health services on mortality. Data availability leads one to restrict the analysis to the socio-economic, demographic and environmental variables provided by the surveys. The 1978 Senegal Fertility Survey, which includes a maternity history, is still the most important source for this study, to which can be added the differential mortality data supplied by the multi-round surveys, notably that of 1970-1971.

The following sections deal with differential mortality based on Senegal Fertility Survey data. The tables used for this analysis were produced by the Population Division of the United Nations. These tables provide estimates of neonatal and post-neonatal mortality, and mortality at ages 1 to 5 years, based on the survival of births in the maternity histories of the women. These estimates are probably strongly biased, owing to errors related to ages. It is assumed that these biases are constant, which is certainly incorrect: for example, in an urban situation one can expect better estimation of ages, owing to the presence of the registrar's office. This leads in the direction of an underestimation of the urban-rural differences in post-neonatal and infant mortality and and overestimation of such differences in mortality at age 1 to 5 years; that is, in rural areas recorded mortality under age 1 will be too low and recorded mortality between ages 1 and 4 too high.

The mortality given is for the cohorts born in 1968 and after in the case of those under 1 year of age, and for the cohorts born in 1967 and after for those aged 1 to 5 years. The statistical significance tests are based on a simplifying hypothesis: the sample was considered to be of the simple random type, or, in other words, the cluster effect, estimated as ranging from 0 to 13 per cent, was disregarded (Enquête Sénégalaise sur la Fécondité, 1978, Rapports nationaux, annexe 7).

Demographic factors

Neonatal, post-neonatal and childhood mortality vary according to sex, order of birth, interval between births, mother's age at the time when the child was born and her age on first marrying (see table 80). These are a group of variables that might be called demographic, which have a relatively mechanical impact on mortality through well-known biological phenomena: mortality for girls is generally lower than that for boys, except in populations with very high death rates; first-born children, those of very young or very old mothers and children issuing from closely spaced pregnancies generally have a higher mortality rate than others.

* Prepared by M. Garenne.

Table 80. Neonatal, post-neonatal and childhood mortality rates, by certain demographic characteristics

Demographic characteristics	*Neonatal*	*Post-neonatal*	*Childhood*
	(rates per 1,000 persons at risk)		
Sex of child:			
male	56.2	73.4	175.1
female	41.3	65.1	179.2
Birth order:			
1	63.1	69.4	177.2
2	43.9	64.0	175.5
3-4	45.1	79.1	171.0
5-6	43.0	67.0	159.7
7 +	50.7	63.3	205.7
Length of previous birth interval (in months):			
0-11	209.3	137.9	125.0
12-23	63.6	71.3	160.0
24-35	40.5	68.4	189.2
36-47	36.9	78.3	184.6
48 +	42.4	47.1	138.2
Mother's age at birth of child (in years):			
15-19	64.2	76.4	192.4
20-24	44.1	73.1	174.5
25-29	39.1	69.0	159.2
30-34	41.7	65.5	183.8
35-39	60.4	55.4	177.7
40-44	63.0	42.1	200.0
Mother's age at marriage (in years):			
less than 15	49.7	78.5	198.0
15-17	49.3	69.9	184.4
18-19	48.1	59.1	151.0
20-21	49.5	40.1	84.7
22-24	35.1	49.6	50.0
25-29	20.4	25.0	93.0

Source: 1978 Senegal Fertility Survey.

Note: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

The results of the Senegal Fertility Survey generally agree with the same phenomena verified in other populations, but with a certain number of peculiar features worth noting: While neonatal mortality is significantly lower in girls, there are no differences between the sexes as for post-neonatal mortality or mortality from 1 to 5 years of age. This is also observed in Ngayokhème, where there is no evidence of any differential treatment between boys and girls. This appears rather to be attributable to both the high level of mortality and the epidemiologic environment of the country: in tropical or Mediterranean-type countries there tends to be little sex difference in mortality for low life-expectancy values, with the exception of the Indian sub-continent, where the excess mortality among girls is due to differential treatment of children according to sex.

Births that come first in order and the children of women aged less than 20 years show higher neonatal mortality than others. This is due in all likelihood to lower weight at birth. The relationship between mortality and mother's age or order of birth is generally a U-shaped curve: in other words, mortality is higher at the ends. Here, an exception to this rule can be noted: post-neonatal mortality is lower in the case of women aged 35 and over. This perhaps involves a bias in the survey (errors concerning ages or omissions relating to children who died). The relationship with the spacing of births is quite clear-cut in the case of neonatal mortality.

The relationship to age at the time of the first marriage is less biological in nature than for other variables: what is involved is principally a correlation with the mother's status, and her level of education, in particular, as women with higher levels of education generally have later ages at marriage. In general, the children of women who marry later have a much lower mortality rate, which also proves true here.

Regional, cultural and socio-economic factors

Mortality in infancy and childhood shows marked variations according to region of residence, ethnic group and religion (see tables 81 to 83).

The effect of the region of residence covers several factors: first of all, the urban/rural dichotomy, which explains why the Cap Vert region, basically consisting of Dakar, the capital, has a considerably lower mortality than the other regions (see also section C above); next, the epidemiologic environment, variations in which are linked especially with fluctuations in rainfall, the relief of the country being uniformly flat; and finally, ethnic group, which exhibits substantial regional clustering.

There are also several regions in Senegal with relatively high mortality. The regions with the highest rainfalls (Casamance and Sénégal Oriental) have very high mortality rates; they are also the regions that are the most isolated and the least well equipped from the health-facilities standpoint. The ground-nut basin has a higher-than-average mortality rate, with one more or less favoured zone (the area of Thiès, which is more urbanized and better equipped) and one very high mortality zone (that of Diourbel). The level of the Louga region is close to that of Sine-Saloum. The Fleuve region shows a remarkably low mortality rate, which stands strongly in contrast to the results of the survey done in 1957 (not shown). Even if this region involved only the mid-valley area, thus leaving out the more highly developed area of Saint-Louis, there still appears to have been a significant decrease in mortality in this region, from a level comparable to the least favoured regions before independence to a level intermediate between Cap Vert and the other regions in the 1970s. This decline in mortality can be explained in terms of the large amount of emigration abroad from this region, which appreciably increased the availability of income and may have transformed attitudes toward disease and illness. Lastly, the Cap Vert (Dakar) region shows a mortality that is roughly half as high as the national average; this can be traced to a higher standard of living, a relatively high educational level and the availability of many health facilities (one third of the hospitals and three fourths of the doctors are in Cap Vert).

Differences in mortality according to the mother's ethnic group are less marked, owing to the relative dispersion of such groups throughout the different regions. Two groups, however, show definitely above-average mortality: the Malinke, concentrated in the regions that have high mortality rates (Casamance and Sénégal

TABLE 81. NEONATAL, POST-NEONATAL AND CHILDHOOD MORTALITY RATES, BY REGION OF RESIDENCE

Region	*Neonatal* (rates per 1,000 persons at risk)	*Post-neonatal*	*Childhood*
Cap Vert	32.8	34.8	72.0
Casamance	73.0	103.6	199.6
Diourbel	41.1	76.4	298.1
Fleuve	43.4	65.5	135.8
Sénégal Oriental	66.3	90.1	204.3
Sine Saloum	52.2	79.4	189.3
Thiès	44.0	53.3	194.9
Louga	40.6	62.7	216.4
National average	48.9	69.3	177.1

Source: 1978 Senegal Fertility Survey.
NOTE: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

TABLE 82. NEONATAL, POST-NEONATAL AND CHILDHOOD MORTALITY RATES, BY MOTHER'S ETHNICITY

Mother's ethnicity	*Neonatal* (rates per 1,000 persons at risk)	*Post-neonatal*	*Childhood*
Wolof	36.9	53.7	191.2
Poular	54.2	71.3	146.9
Malinke	74.2	104.7	226.2
Serer	60.0	75.0	203.4
Dyola	72.8	76.3	118.9
Other	48.6	96.3	146.1
National average	48.9	69.3	177.1

Source: 1978 Senegal Fertility Survey.
NOTE: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

TABLE 83. NEONATAL, POST-NEONATAL AND CHILDHOOD MORTALITY RATES, BY MOTHER'S RELIGION

Mother's religion	*Neonatal* (rates per 1,000 persons at risk)	*Post-neonatal*	*Childhood*
Muslim	48.8	70.3	180.6
Catholic	43.2	35.5	91.5

Source: 1978 Senegal Fertility Survey.
NOTE: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

Oriental) and little urbanization [$q(5) = 0.3586$] and the Serer, concentrated in the Sine region, and also not highly urbanized [$q(5) = 0.3074$].* Attention should be called to the fact that Serer mortality determined on the basis of the Senegal Fertility Survey is fairly close to mortality in the Ngayokhème study area. This confirms the good quality of the Survey results: $q(1)$ and $q(5)$ measured on the basis of birth survival were 12 per cent lower than the corresponding Ngayokhème values for the period 1972-1980; this difference can easily be explained by the presence of Serer in urban areas and random fluctuations.

Differences in mortality according to the mother's religion probably reflect a difference in level of education: Christians have greater chances of benefitting from modern education through the system of mission schools.

The modernization process has a major impact on mortality, and on infant and child mortality in particular; so much so, in fact, that infant and child mortality rates are sometimes used as indicators of development, just as per capita income is. Among the variables used by demographers, it is generally the level of education, and particularly the mother's education, that has the greatest impact on child mortality (Caldwell, 1979). Income, urbanization and socio-economic status are also variables that determine the level of mortality, but their impact is generally slighter, *ceteris paribus*.

Univariate analysis of the results of the Senegal Fertility Survey confirms these general results. Large univariate differentials are found in early age mortality according to mother's and father's education (see table 84). In general, the higher the educational level, the lower mortality is. Some inexplicable differences do exist, however, in table 84, no doubt due to sampling and non-sampling errors in the data. These results also show the profound dichotomy that exists between urban and rural areas, reflected in a total mortality under age 5 years more than twice as high as that in rural areas (see table 85).

TABLE 84. NEONATAL, POST-NEONATAL AND CHILDHOOD MORTALITY RATES, BY MOTHER'S AND FATHER'S EDUCATION

Parent's education	*Neonatal*	*Post-neonatal*	*Childhood*
	(rates per 1,000 persons at risk)		
Mother			
No school	51.0	72.6	187.9
1-3 years	21.4	31.6	112.5
4-6 years	46.2	47.3	28.2
7-9 years	. .	33.7	29.4
10+ years	. .	15.9	. .
Father			
No school	53.0	74.8	200.3
1-3 years	90.9	111.1	76.9
4-6 years	26.0	40.0	75.0
7-9 years	-	22.3	43.5
10 + years	27.6	37.9	19.2

Source: 1978 Senegal Fertility Survey.

NOTE: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

TABLE 85. NEONATAL, POST-NEONATAL AND CHILDHOOD MORTALITY RATES, BY URBAN OR RURAL RESIDENCE

Type of residence	*Neonatal*	*Post-neonatal*	*Childhood*
	(rates per 1,000 persons at risk)		
Urban	34.1	37.7	86.5
Rural	55.9	84.5	222.5

Source: 1978 Senegal Fertility Survey.

NOTE: The neonatal mortality rate is the proportion of children born who died within a month after birth. The post-neonatal mortality rate is the proportion of children surviving for one month after birth who died before the first birthday. The childhood mortality rate is the proportion of children surviving to their first birthday who died before their fifth birthday. For the calculation of neonatal and post-neonatal rates, children born during 1968 or after are considered. For calculation of childhood rates, children born in 1967 and after are considered.

Multivariate analysis of the factors of infant and childhood mortality analysis

The mortality factors indicated above are in fact all correlated, and what one would like to obtain is the effect of each factor, independently of the other factors. There exist several methods of statistical investigation whereby this problem can be approached; among them are the "proportional hazards" models (Breslow, 1984) and the regression models developed by Trussell and Preston (1984). The "proportional hazards" models require knowledge of the precise age at death. These models were not used, owing to the errors in age at the time of children's deaths. In fact a model was developed that is very close to Trussell and Preston's, but has the advantage of limiting the bias in the ratio (of observed number of child deaths to expected number of child deaths) in low-parity women (Garenne, forthcoming).

Using this model, three regression analyses were carried out. The first included environmental variables (see table 86), the second included demographic variables (see table 87), and the third included occupation variables (see table 88). In all three analyses urbanization and education/literacy variables were included because these variables are ordinarily considered the principal factors of variation in mortality.

The results show that urbanization (living in an urban environment as opposed to living in a rural environment) appears as the dominant factor of infant and child mortality, accounting for 58 to 72 per cent of the total variance explained by the models. The educational level of both mother and father (but especially that of father), on the contrary, appears to be a less important variable, and even not significant when one controls for demographic variables. This result is quite remarkable and contrary to what was found by Trussell and Preston (1984) in Asiatic countries.

Multivariate analysis of regional and cultural factors yields interesting results that modify the picture given by univariate analysis. In the first place, the ethnic variable

* The $q(5)$ values are calculated from table 81.

TABLE 86. RESULTS OF THE REGRESSION OF CHILD MORTALITY ON SOCIO-ECONOMIC VARIABLES AND ENVIRONMENTAL VARIABLES, 1978 SENEGAL FERTILITY SURVEY

Independent variable[a]	*Regression coefficient*	*Standardized regression coefficient*	*F Statistic*[b]
Urban	−0.39444	−0.17820	56.581
Ethnic group: Malinke	+0.50225	+0.10175	25.177
Educational level of mother[c]	−0.13608	−0.06031	10.401
Region: Casamance	+0.21650	+0.07449	6.603
Ethnic group: Serer	+0.17846	+0.06179	5.634
Region: Thiès	−0.16306	−0.05213	4.448
Region: Fleuve	−0.13950	−0.03948	2.612
Region: Diourbel	+0.11966	+0.03428	2.055
Region: Sénégal Oriental	+0.11956	+0.03008	1.629 (NS)
Religion: Christian	−0.26598	−0.05149	1.365 (NS)
Ethnic group: Poular	−0.04731	−0.01925	0.540 (NS)
Religion: Muslim	−0.11946	−0.02499	0.317 (NS)
Educational level of father[c]	−0.00111	−0.00789	0.202 (NS)
Ethnic group: Wolof	+0.02663	+0.01268	0.169 (NS)
Region: Sine-Saloum	−0.02144	−0.00847	0.088 (NS)
Region: Louga	−0.01984	−0.00548	0.051 (NS)
Ethnic group: Dyola	+0.01461	+0.00269	0.018 (NS)

NOTE: See text for description of regression model.
R^2 = 0.08092 (F = 15,807), N = 3,122 women having at least 1 child.
[a] Reference categories are residence = rural, ethnic group = other, region = Cap Vert, religion = other.
[b] NS indicates not significant.
[c] Educational levels are based on a scale of 0 to 5.

TABLE 87. RESULTS OF THE REGRESSION OF CHILD MORTALITY ON SOCIO-ECONOMIC VARIABLES AND DEMOGRAPHIC VARIABLES, 1978 SENEGAL FERTILITY SURVEY

Independent variable[a]	*Regression coefficient*	*Standardized regression coefficient*	*F Statistic*[b]
Urban	−0.40392	−0.18248	91.929
Mother's age	−0.01849	−0.15814	72.860
Age at first marriage	−0.02940	−0.08230	19.986
Literacy of father	−0.12988	−0.06257	12.319
Number of unions	0.05383	0.03413	3.528
Educational level of father[c]	−0.01265	−0.00902	0.267 (NS)
Educational level of mother[c]	−0.01496	−0.00663	0.118 (NS)

NOTE: See text for description of regression model.
R^2 = 0.08709 (F = 41,731), N = 3,122 women having at least 1 child.
[a] Reference categories are residence = rural, literacy status = illiterate, number of unions = 1.
[b] NS indicates not significant.
[c] Educational levels are based on a scale of 0 to 5.

TABLE 88. RESULTS OF THE REGRESSION OF CHILD MORTALITY ON SOCIO-ECONOMIC VARIABLES AND OCCUPATIONAL VARIABLES, 1978 SENEGAL FERTILITY SURVEY

Independent variable[a]	*Regression coefficient*	*Standardized regression coefficient*	*F Statistic*[b]
Mother is farmer	+0.21636	+0.10476	21.176
Urban	−0.15801	−0.07138	7.914
Mother's education[c]	−0.09193	−0.04074	4.352
Father is farmer	+0.10745	+0.05112	3.939
Mother paid in cash before union	−0.09650	−0.02038	1.261 (NS)
Father paid in cash	−0.09759	−0.04036	0.903 (NS)
Father is employer	−0.06552	0.02841	0.428 (NS)
Father is managerial-level or office employee	+0.02478	0.00568	0.083 (NS)

NOTE: See text for description of regression model.
R^2 = 0.06817 (F = 27,992), N = 3,122 women having at least 1 child.
[a] All reference categories are "other".
[b] NS indicates not significant.
[c] Educational levels are based on a scale of 0 to 5.

appears very important, even when one accounts for urbanization, level of education and region. Two ethnic groups appear to be particularly high-risk: the Malinke and the Serer. This suggests differential behaviours for these two groups, perhaps in terms of nutrition or hygiene, which might affect mortality. After taking into account differences in urbanization and educational level, two regions appear to be high-risk regions (Casamance and Diourbel) and two regions seem to be relatively low-risk (Thiès and Fleuve). The Thiès region is in fact more developed than the others, outside of Cap Vert, and has the advantage of a more complete health-service infrastructure. The case of the Fleuve region has already been mentioned, and the fact that this region, *ceteris paribus*, now has a lower mortality, whereas this was not the case before independence, suggests that a profound transformation has taken place there, which one might expect to be connected with the intense international migrations that have occurred and the monetary availability resulting from them. Casamance has a damper climate and probably has a greater prevalence of infectious and parasitic diseases, such as malaria. The case of Dourbel is as yet unexplained; a sampling error or bias may be involved.

Finally, religion appears to be not a significant factor when one controls for other regional and cultural variables.

The results of the regressions on demographic variables pose a new problem. When one accounts for residence (urban), mother's age, age at the time of the first marriage, number of marriages and literacy of the husband, the net effect of the educational levels of the husband and wife disappears. This suggests that in this situation, residences being the same, the effect of the level of education of the mother on mortality essentially operates through an increase in age at maternity and perhaps through marriage stability rather than through a change in behaviour. As for the husband, it appears that the degree of literacy (the simple fact of knowing how to read, whether in French or Arabic, whether learned in school or not), has a very appreciable impact on mortality, whereas the net effect of having been to a modern school does not. In this regard it is worth noting that 45 per cent of fathers stated they could read a newspaper or a book, whereas 86 per cent reported they had never been to a modern school.

The results of regression on occupational variables confirm the dichotomy of urban versus rural environment. The majority of the variables described in univariate analysis turn out non-significant: this is due in part to the small size of the sample, but also to their small impact.

Seasonal variations in mortality

The endemic and epidemic diseases responsible for a large percentage of child deaths are often characterized by a seasonal component. This is the case, in particular, of malaria, which is more prevalent during the wet season, and also of measles, whooping-cough and meningitis, which hardly ever appear outside of the dry season. These differences are explainable in terms of the manner in which these diseases are transmitted: the rainy season is characterized by the proliferation of anopheles mosquitoes, carriers of malaria.

The seasonality of deaths is not uniform throughout all of Senegal, however, and two ecologic zones can be distinguished: the outlying regions of Fleuve and Sénégal Oriental, which show no really marked seasonal variations, and the other regions, in which deaths are greatly concentrated within the rainy season. This concentration during the months of August, September and October is most intense in the ground-nut basin (47 per cent of all deaths in Sine-Saloum, 44 per cent in Thiès, 46 per cent in Diourbel) and considerably less so in Cap Vert (35 per cent) and in Casamance (35 per cent) (see table 89). This concentration of deaths during the wet season is in all probability linked with malaria: at Garki, Nigeria, in a savannah area, the seasonal nature of deaths is disappearing following the eradication of malaria (Molineaux and Gramiscia, 1980). However, while malaria is not of great importance in Cap Vert, its prevalence in Casamance is somewhat stronger than elsewhere. The case of Sénégal Oriental, too, is unexplained. One can hypothesize that the regions of Fleuve and Sénégal Oriental are more sparsely populated, and

TABLE 89. MONTHLY VARIATIONS IN MORTALITY IN 1970, SENEGAL
(*Number of deaths, as a percentage of 1,200*)

Month	*Cap Vert*	*Casamance*	*Diourbel*	*Fleuve*	*Sénégal Oriental*	*Sine-Saloum*	*Thiès*	*Urban areas*	*Rural areas*	*Combined*
January	81	51	67	32	73	65	73	70	62	64
February	97	88	55	134	110	64	78	85	77	80
March	89	73	49	120	113	50	60	79	63	68
April	76	74	54	38	68	54	87	77	65	65
May	84	94	76	101	117	69	73	87	83	83
June	80	63	80	199	117	61	63	83	79	80
July	85	104	92	115	125	68	61	92	88	88
August	101	156	178	131	76	208	81	126	155	150
September	93	138	212	113	118	198	168	130	174	164
October	221	122	158	85	102	155	279	188	156	163
November	105	146	100	94	95	118	106	125	113	115
December	88	92	79	38	86	87	71	58	85	80
TOTAL	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200
August-September-October (%)	35	35	46	27	25	47	44	37	40	40

Source: Enquête Démographique Nationale, 1970-1971 (unpublished data).

that this perhaps reduces the level of transmission of the disease. But it is also possible that other weather factors, such as winds, likewise affect the seasonality of deaths; moreover, the two regions, Sénégal Oriental and Fleuve, are also the hottest regions in the country (Atlas National du Sénégal, plate 6).

Conclusion

What is striking, therefore, in the case of Senegal, is the very marked distinction between urban areas and rural areas: living in an urban environment decreases the risk of death by more than one half with respect to the mean value, all other things being equal. The effects of the educational levels of the wife and the husband are more mixed and less pronounced than expected: the educational level of the wife becomes negligible when one controls for age at birth of child, age at the time of the first marriage, number of marriages, residence, and literacy of the husband. On the other hand, the literacy of the husband, whether in French or in Arabic, appears to be a significant determinant of child mortality.

Occupational variables seem to have little impact. Regional and cultural variables, however, continue to play an important role when one controls for other variables. All these results, which differ considerably from those found in Asiatic countries, suggest that this is a special situation in which, in the process of modernization, the lines are somehow more sharply drawn than elsewhere, and in which it is decidedly an advantage to live or to have lived in an urban area; education or literacy of parents only supplement. Outside of the cities, the principal differences in mortality appear among regions, which suggests different epidemiological environments, and among ethnic groups, which is perhaps due to different behaviours with regard to hygiene and nutrition.

The seasonality of deaths, with a high concentration between August and October, is another striking phenomenon. This concentration of deaths during the rainy season is particularly marked in the ground-nut basin, less so in Casamance and Cap Vert, and nonexistent in Fleuve and Sénégal Oriental. This seasonality is in all likelihood due to epidemiological (especially the prevalence of malaria) and climatic factors.

E. Case study of Ngayokhème, Sine-Saloum, 1963-1981*

The 1963-1981 Ngayokhème case study is an in-depth study of mortality in a rural area of Senegal (Sine). The aim of this study is to present an accurate measurement of mortality in a rural environment, in particular infant and child mortality, to give an estimate of the age pattern of mortality with a view to determining the high-risk periods, and to evaluate certain factors affecting this mortality, in particular environmental factors.

This case study covers a small area of Sine. It cannot under any circumstances be deemed representative of rural Senegal. There are a number of indications, however (e.g. from Khombole, Nioro and Keneba), that the mortality pattern observed at Ngayokhème is not unique, but can rather be considered as characteristic of this region. None the less, this does not prove that it is identical in all parts of Sine-Saloum or in other regions of Senegal.

The environment

The Ngayokhème survey area is located in the north-western part of the region of Sine-Saloum, a few kilometres from Niakhar, the seat of the *arrondissement* of the same name. Ngayokhème is approximately halfway between the two main highways of Senegal leading toward the east: the Diourbel road and the Kaolack road. Ngayokhème is about 5 kilometres from the Bambay-Fatick road (these are two small towns located at either end of these highways). The survey area is connected to the major communication arteries by a system of bush taxis and carts, whereby it is possible to go to Niakhar, Bambey and Fatick.

Sine is situated in the Sudano-Sahelian portion of Senegal (Atlas National du Sénégal, plate 15): i.e., the heart of the peanut-growing zone. The climate is hot and dry between November and June, and hot and humid between July and October, the rainy season (tropical winter season).

During the period 1963-1981, rainfall in the region averaged 549 millimetres (mean for Bambey and Fatick). The rainfall pattern is particularly irregular, with peak values of 900 millimetres (1967) and minimum values of 340 millimetres during the period of drought (1972-1974), as well as in 1968 and 1977.

The survey area has been populated for a fairly long time. The majority of the villages were created prior to 1800, and only one of the area's eight villages was set up after 1900. The region of Ngayokhème was an important part of the old kingdom of Sine. The demographic pressure in it is very high, and the high net rate of out-migration offsets natural growth to a large extent. During the study period (1963-1981), the area gained 1,486 individuals as a result of the excess of births over deaths (4,095-2,609), but lost 899 due to emigration (3,376-4,275).

The resident population was 4,378 in December 1962 and 4,965 in April 1981, which represents a mean increase of 6.88 per 1,000 per year (see table 90).

The villages are administrative units; their structure is quite complex and reflects the history of the population. A village is in the form of a group of hamlets that are fairly independent from one another. The hamlets are in turn divided into compounds, each compound being clearly delimited by a fence.

The population is for the most part Muslim, but there exist a number of communities of animists and Christians, both Catholic and Lutheran. The traditional religions are still practiced by a large portion of the population. Monotheistic religions appeared relatively recently in the region, approximately a century ago. The population is almost exclusively Serer; only a few outsiders, mostly Tukulor and Lebu, inhabit the survey area.

The majority of the adult males are peasants who grow millet and ground-nuts (peanuts). Millet is the basis of the meal. Ground-nuts, a small part of which

* Prepared by M. Garenne.

TABLE 90. POPULATION AND VITAL RATES IN NGAYOKHÈME DURING THE PERIOD 1963-1981

	1963-1981		1963-1971		1972-1981	
	Number	Rate	Number	Rate	Number	Rate
Births	4 095	.04847	1 916	.04682	2 179	.05000
Deaths	2 610	.03089	1 450	.03543	1 160	.02662
Immigrants	2 519	.02981	1 465	.03580	1 054	.02419
Returns	857	.01014	336	.00821	521	.01196
Emigrants	4 274	.05059	1 914	.04680	2 360	.05416
Natural growth	1 485	.01758	466	.01139	1 019	.02338
Net migration	−898	−.01063	−113	−.00276	−785	−.01801
Population growth	587	.00695	353	.00863	234	.00537
Total person-years	84490.5		40921.8		43577.2	
Population as of 1 December 1962: 4 378						
Population as of 15 March 1981: 4 965						

are for self-consumption, are a cash crop that is used for acquiring rice, fish, occasionally meat and a few consumer durables. The growing season is concentrated during the rainy period, and from July to October men and women work all day long in the fields. During the dry seasons, many young men and women go to the neighbouring towns or to Dakar to find small jobs: as fishermen, workers, labourers, itinerant merchants, maids etc. The family's monetary revenue is very low and depends in large measure on the year's harvest.

The village of Ngayokhème has a primary school that opened in 1962. For the 1980-1981 school year 149 children (78 boys and 71 girls) were registered. Among the children aged from 6 to 11 years residing in the village of Ngayokhème, only 29.4 per cent attended school in 1981, which is higher than the average for the survey area (13.8 per cent). The other villages have no primary schools, but the majority of them, except the smallest, have a Koran school, and one of them has a private Lutheran school. The Niakhar school was opened in 1935, and another nearby school is kept by Catholic nuns. But only a very few pupils (4.6 per cent) attend these schools located outside of the survey area. The percentage of children who attend neither modern schools nor Koran schools is still very high (73.9 per cent). The educational level of adults is also very low. In 1981 only 11.3 per cent of the men aged 15 to 49 years had attended modern school for at least six years, and only 3.6 per cent of the women aged 15 to 49 knew how to read and write.

Within the survey area there are virtually no health care centres. The nearest dispensaries are those of Niakhar, Toucar and Diohine. A primary health care system was installed throughout the entire region by a Belgian woman nurse in December 1979; this system is now in operation in all the villages of the survey area, in spite of management difficulties and efficiency that varies from village to village. It consists of a team of two villagers, a man and a woman, selected and in part remunerated by the population, who are in charge of providing basic care and taking care of childbirth. They have consulting hours at regular intervals in a small hut built for that purpose, but are on call at all times. The principal drugs that are available are antidiarrhoeals, antimalarials and antiseptics for treating wounds, injuries and eye diseases. The system also serves as a basis for vaccination campaigns and malaria-prevention campaigns. The system has been in operation since 1980 and is based on self-financing: patients must pay for each tablet or each injection that they receive.

Outside of this modern medicine system, there is a whole network of traditional doctors that people consult just as much as the nurses or nursing aids. There are several categories of traditional doctors: healers using massage, marabouts using prayers and greegrees, specialists in plants and natural potions, as well as magicians.

The survey

The Sine-Saloum demographic survey has been described in a number of earlier documents (Cantrelle, 1969; Cantrelle and Léridon 1971) There is a population register that is annually updated. Every year the survey workers visit the households in the survey area and ask for information on all the events that have taken place since the previous visit, namely: births, deaths, migrations, changes in marital status, vaccinations against measles, cases of measles, weaning, puberty, pregnancy and still births. The information pertaining to births, deaths, marital status and changes in residence is complete for all the individuals who ever resided within the survey area; it is incomplete with regard to weaning, measles, pregnancies and stillborn babies; it appears to be complete for puberty and vaccinations. The survey was first started in the entire *arrondissement* of Niakhar (approximately 30,000 inhabitants), but was subsequently reduced to the smaller area of Ngayokhème (approximately 5,000 inhabitants). All the data used hereafter pertain to the Ngayokhème area alone, for the period from December 1962 to April 1981.

The survey has been in progress since December 1962, but there have been several interruptions: 1967, 1975 and 1976. It is generally conducted at the beginning or in the middle of the dry season, from January to April. The first part of the survey (1963-1973) was coded in 1974, the second part (1974-1981) in 1981, with a few changes. For example, the definition of residency was modified; in order to be considered a resident between two rounds, an individual must have been present in the area at least six months, or else during the last rainy season.

In 1981 all the already coded data were reviewed one by one and re-recorded to correspond to the new definition.

The quality of the data pertaining to age is good for children born during the survey. For those who were residents in 1962, or those who immigrated subsequently, knowledge of the age involves a high degree of uncertainty. The population pyramid in 1962 shows pronounced disruptions, particularly between the ages of 1 and 7 years. The 1981 pyramid, on the other hand, whose base is made up essentially of children born during the survey, is far more regular, at least up to age 15. The Sine peasants have a traditional calendar based on seasons and growing periods which enables the investigator to translate fairly easily the date of an event into the Gregorian calendar.

One can consider that events are known to within approximately a month, and that precision as to ages and intervals between events is therefore thoroughly satisfactory. All the data relating to infant and child mortality were painstakingly checked and, save omissions from the survey (see below), their quality can be considered excellent.

The survey is conducted only once a year. There thus exists a risk of omission of deaths of children born between two rounds who died shortly after they were born. In addition, a child is baptized only on the seventh day after birth, and the family does not like to speak about a child that was not baptized. Attention has already been called to this risk of underestimation by Cantrelle (1969). The data on the follow-up on pregnancies observed during the period 1972-1981 (table 91) during which the coverage of pregnancies recorded in the survey represented 24.6 per cent of the births observed (which is satisfactory considering the three interruptions in 1975, 1976 and 1979 and the periodicity of the survey) show upon re-examination that this underestimation was considerable. The statistical tests are not significant, because the number of deaths was too low, but it appears that 30 per cent of the deaths in the first month were omitted during the period. This figure is perhaps overestimated, but the mortality of children resulting from pregnancies that had been recorded in the survey is always higher than the mean, for each year as well as during the dry season and during the rainy season. It is this consistency among the figures that led us to correct neonatal mortality by 30 per cent in all the computations below. This implies a correction of infant mortality by approximately 10 per cent, or the omission of 2 per cent of births. The interruptions of the survey affected data quality, and the quality of the survey is probably now better than its average experience. However, there is no rigorous proof of any very marked omission during the years in which the survey did not take place, for the population numbers are insufficient. Only the specific case of the year 1975 shows a sizeable error regarding age at death, with a tendency for this age to be overestimated: there are too many deaths from age 1 to 5 years for the number of deaths from age 0 to 1 year ($q(1) = 0.14582$ for a $q(5)$ of 0.49084).

TABLE 91. COMPARISON OF PROBABILITY OF DYING BETWEEN THE AGES OF 0 AND x YEARS, $q(x)$, OBSERVED IN THE SURVEY WITH THOSE BASED ON FOLLOW-UP OF PREGNANCIES (CHILDREN BORN DURING THE SURVEY)

Age x	*q(x) based on pregnancies noted between 1972 and 1981 (N = 531)*	*q(x) observed in 1972-1981 survey (N = 2,155)*
1 week	.04702	–
1 month	.07367	.05637
1 year	.15543	.14205
2 years	.25022	.22320
3 years	.31561	.29771
5 years	.38935	.35645

With these restrictions on data quality the analysis of the age pattern of infant and child mortality at Ngayokhème, as well as the changes in it over the study period, are considered below. All the computations that follow were made by calculating the person-years lived at risk in each case. Inasmuch as the survey gives only the month of the event, a day was selected in a random drawing for each event, in order to provide ages in real values with three decimal places. Whenever the month was unknown, the month, too, was assigned randomly. Details on the computations are given in Garenne (1982).

Mortality: levels, trends and annual variations

Levels during the period 1963-1981. The mortality rate of the population in the survey area was extremely high during this period: the mean life expectancy between 1963 and 1981 was 34.6 years. This is lower than the life expectancies of most other contemporary populations outside of West Africa. McGregor (1979) estimates life expectancy at Keneba, Gambia, at a value close to this, and mortality in most of the West African countries is lower than the world average. This elevated mortality rate is due first and foremost to extremely high mortality among infants and children: the probability of dying before reaching the age of 5 years for the children born during the survey was 0.426, and infant mortality was 0.182 during the same period.

Trends. Table 92 shows a marked drop in mortality during the period. The increase in life expectancy is due entirely to a decrease in mortality from age 0 to 5 years; expectation of life at age 10, for example, did not undergo any significant change. The decline in infant/child mortality was far from regular; two periods can be distinguished: 1963-1971, characterized by marked annual variations but without any trend, and 1972-1981, which showed slighter annual variations but a clearly marked trend. These trends can be estimated by means of a regression as a function of date. The results indicate that $q(1)$, the probability of dying before the age of 1 year, decreased from a level of 0.21498 in 1963-1971 to a value estimated at 0.08847 in 1981, and that $q(5)$, the probability of dying before the age of 5 years, diminished from a level of 0.39200 in the first period to an estimated 0.25760 in 1981. The result of this was an increase in life expectancy from 30.3 in 1963-1971 to an estimated 50.8 in 1981. This life-expectancy gain of 20 years is entirely due to an approximate 50 per cent drop in mortality at age 0 to 5 years. The picture is not as optimistic as it may first appear because we estimate in the next section that most of the decline in under-5 mortality is a result of reduced rainfall over the period.

TABLE 92. MORTALITY BY YEAR IN NGAYOKHÈME (ALL RESIDENTS) AND ITS RELATIONSHIP TO RAINFALL AND MILLET AND GROUND-NUT PRODUCTION, 1963-1981

Year	Probability of dying between ages 0 and 1	Probability of dying between ages 0 and 5	Life expectancy at age 0	Life expectancy at age 10	Rainfall (mm)	Production in previous year: Ground-nuts (tons)	Production in previous year: Millet (tons)
1963	.212	.458	34.0	55.7	667	7 650	9 570
1964	.247	.583	24.9	51.9	715	9 200	9 720
1965	.169	.462	30.9	48.8	623	10 200	9 000
1966	.278	.561	24.9	48.7	700	10 450	11 700
1967	.209	.363	40.8	55.2	900	5 400	4 200
1968	.168	.349	41.1	54.8	342	13 428	10 730
1969	.254	.632	21.0	45.8	808	5 542	5 500
1970	.222	.444	34.1	53.4	487	5 400	8 916
1971	.227	.557	27.9	50.1	704	6 340	6 800
1972	.201	.420	36.4	52.2	344	12 800	13 600
1973	.203	.422	30.4	42.6	359	2 079	1 380
1974	.194	.435	36.2	53.3	466	5 600	8 400
1975	.146	.491	32.1	53.4	600	8 450	13 700
1976	.180	.408	31.7	44.3	546	11 994	4 655
1977	.186	.349	44.5	58.7	341	14 331	10 229
1978	.136	.350	45.8	60.8	552	5 571	8 194
1979	.067	.280	46.4	54.7	491	9 380	11 621
1980	.112	.243	50.7	59.3	459	4 294	6 496

Annual variations. Outside of these trends there are marked yearly variations, particularly for mortality from age 0 to 5 years. The sample is small, but despite this the majority of these fluctuations lie outside of confidence limits of two standard deviations under a binomial model. Infant and child mortality showed peaks in 1964, 1966, 1971 and 1975. All these high-mortality years were also years with large amounts of rainfall (see table 92). Indeed, rain has a major impact on the incidence of malaria and diarrhoea, which are the chief causes of death between the ages of 0 and 5 years. It is possible that ground-nut and millet production (the region's two principal crops) also had an effect; in any event, 1968 production was lower than average, and the highest adult mortality appeared at the end of the drought period (1972-1974).

An attempt was made to estimate the influence of each of these variables on mortality, but unfortunately the results with agricultural crops proved quite unstable, which is probably due to the poor quality of the data. However, the correlation of $q(5)$ with time and with the amount of rainfall was far stronger and definitely more stable. Furthermore, crop production levels do not show any trend, and one can expect that the decline in 0-to-5-year-old mortality might be related in part to the decrease in rainfall between the periods 1963-1971 and 1972-1981. A multiple regression on time and rainfall yields a value of $q(5) = 0.5908$ in 1963, with 698 millimetres of rain, and 0.23625 in 1980, with 424 millimetres of rain. Had the amount of rainfall remained constant at 698 millimetres, $q(5)$ would have equalled 0.43844 in 1980. This relationship suggests that the decrease in rainfall explains 57.06 per cent of the decline in mortality from age 0 to 5 years. This result must be viewed with considerable caution, for it is based on a small number of years, and the values of the independent variables are greatly affected by random fluctuations.

Age pattern of infant/child mortality in the period 1963-1981

Mortality from 1963 to 1971. In view of the fact that there were significant changes in the levels of mortality, the two periods, 1963-1971 and 1972-1981, will be studied separately. Table 93 gives the mortality rates according to age for the children born during the survey.

TABLE 93. DEATH RATE ACCORDING TO AGE AND PERIOD FOR NGAYOKHÈME, 1963-1981[a]

Age (in months)	Period: 1963-1971 (number of deaths in parentheses)	Period: 1972-1981 (number of deaths in parentheses)	Ratio of later period to earlier
0-5	.19882 (172)	.20099 (199)	1.01091[b]
6-17	.24420 (319)	.11377 (199)	0.46589
18-35	.17807 (216)	.09473 (193)	0.75278
36-59	.04544 (44)	.04457 (91)	0.98085[b]
60-119	.01433 (10)	.00960 (38)	0.66992[b]

[a] Applies to children born during the survey.
[b] Not significantly different from unity.

This pattern has already been studied in previous documents (Cantrelle and Léridon, 1971; Garenne, 1981) and exhibits six characteristic features:

(*a*) Very high mortality: $q(5) \cong 0.50$;

(*b*) Concentration of deaths between 6 and 36 months of age (71.2 per cent);

(*c*) Level of mortality that increases again after 6 months and begins to decline regularly only after 30 months of age;

(*d*) First high-risk period between 6 and 18 months;

(*e*) Second high-risk period between 18 and 36 months;

(*f*) Concentration of deaths during the wet season (50 per cent from August to October).

The ratio of child mortality (ages 1 to 5 years) to infant mortality (RCIM) is very high: ${}_4q_1/{}_1q_0 = 1.643$. Garenne's thesis (1982) involves the use of another indicator of the ratio between child mortality and infant mortality:

$$RCIM = (4 + e_5 - e_1)/(1 + e_1 - e_0).$$

This ratio has good properties and is more sensitive than the ratio mentioned above. It ranges from 0.1 to 1.2 in European types of populations. It rapidly decreases as life expectancy increases, in more or less linear fashion. It is higher in the Coale and Demeny South model and lower in the East model. It is sensitive to a change in mortality between 6 and 18 months, for it takes into account the mean age at death in each age group. Its value here is 2.446, which is considerably higher than any value recorded in any population. This ratio varies primarily with the level of mortality, as defined by the expectation of life at birth, but also with climatic regions. So far as we know, there is no tropical rural mortality table with the same life expectancy, but a regression on the existing tropical tables (Bangladesh, El Salvador, Guatemala, India and Sri Lanka) predicts a ratio of child to infant mortality (RCIM) value of 1.625 at 30 years life expectancy (regression of the logarithm of RCIM on life expectancy; for further details, see Garenne, 1982). This indicates that mortality from age 1 to 5 years in this region is extraordinarily high compared with other tropical regions of the world, even when the level-of-mortality effect is eliminated.

The change in mortality: 1972-1981. As indicated above, 0-to-5-year-old mortality declined considerably during the period 1972-1981, and this reduction shows a high degree of correlation with the decline in the amount of rainfall that followed the drought in the Sahel from 1972-1974. Tables 93, 94, and 95 indicate that this drop in mortality affected only certain age groups: it was primarily concentrated at ages 6-17 months (53.4 per cent decrease) and 19-35 months (24.7 per cent), while the changes prior to age 6 months, after 36 months and after 5 years were not statistically significant.

TABLE 94. LIFE TABLE FROM AGE 0 TO 10 YEARS FOR NGAYOKHÈME, BOTH SEXES COMBINED, 1963-1971[a]

Age at beginning of interval	*Length of interval, in months (n)*	*Number of deaths observed*	${}_nq_x$	l_x	${}_nd_x$
0	1	89	.060	1 000	60
1 month	2	30	.017	940	16
3 months	3	53	.031	924	29
6 months	3	97	.061	895	55
9 months	3	101	.071	841	60
12 months	3	70	.056	781	44
15 months	3	51	.046	737	34
18 months	3	67	.068	704	46
21 months	3	46	.050	658	33
24 months	3	23	.027	625	17
27 months	3	35	.045	608	27
30 months	3	27	.037	581	22
33 months	3	18	.027	559	15
3 years	12	37	.065	544	35
4 years	12	7	.017	508	8
5-9 years	60	10	.069	500	34

[a]Applies to children born during the survey.

TABLE 95. LIFE TABLE FROM AGE 0 TO 10 YEARS FOR NGAYOKHÈME, BOTH SEXES COMBINED, 1972-1981[a]

Age at beginning of interval	*Length of interval, in months (n)*	*Number of deaths observed*	${}_nq_x$	l_x	${}_nd_x$
0	1	121	.072	1 000	72
1 month	2	29	.014	928	13
3 months	3	49	.025	914	23
6 months	3	55	.029	892	26
9 months	3	47	.026	866	22
12 months	3	51	.029	843	25
15 months	3	46	.028	819	23
18 months	3	29	.019	796	15
21 months	3	33	.022	781	17
24 months	3	41	.029	763	22
27 months	3	36	.027	741	19
30 months	3	33	.026	721	19
33 months	3	21	.017	703	12
3 years	12	63	.057	690	39
4 years	12	28	.029	651	19
5-9 years	60	38	.047	632	30

[a]Applies to children born during the survey.

As a result of the concentration of the drop in mortality about the first birthday, there was virtually no change in the ratio of child mortality to infant mortality: ${}_4q_1/{}_1q_0 = 1.594$. The RCIM index decreased considerably to 1.972 as a result of the decrease in the mean age at death between the ages of 0 and 1 year, and its increase between 1 and 5 years.

It is easier to compare the new mortality pattern in the period 1972-1981 with known patterns in tropical areas, for the expectation of life at birth is now close to 40 years (39.247). Using the same regressions of the logs of ${}_1q_0/{}_4q_1$ and RCIM on life expectancy one can predict an infant mortality of 0.16091 (as compared with the observed value of 0.15676), child mortality of 0.16788 (observed value: 0.24993) and an RCIM of 1.1857 (observed: 1.9723). Here again, infant mortality turns out to be very close to the predicted value, but child mortality differs radically, being 48.9 per cent higher than in other tropical tables. These values predicted by regression are close to the values given by the new United Nations (1982) tables for South Asia (Heligman, 1984). At a life expectancy of 40 years, the model for South Asia gives ${}_4q_1 = 0.14125$.

The first high-risk period: age 6-17 months. The age pattern of mortality below the age of 5 years at Ngayokhème thus appears to be exceptional when compared with those of other tropical mortality tables: i.e., those of the Indian Sub-continent (Bangladesh, India, Sri Lanka) and those of Central America (Guatemala, El Salvador, Mexico). Its most outstanding feature is the high mortality level from age 6 to 17 months and from 18 to 35 months; high mortality at age 6 to 17 months is also found, for example, in the Punjab, one of the rare rural tropical areas for which relatively precise data are available (Wyon and Gordon, 1971).

The period from 6 to 17 months is a high-risk period for several reasons. In the first place, in about the sixth month the child is no longer protected by the antibodies inherited from the mother, and is thus in a fragile immunological situation. It has to build up its own immunity according to the assaults that it undergoes. It is also a period of new exposure to risks from dietary additions. Indeed, at about the age of 6 months the mother's milk no longer suffices and mothers start to give the child paps made of millet, milk, or any other food prepared for adults that the child will accept. This high-risk period after age 6 months is particularly marked in tropical regions (Khanna study), but no doubt also existed in nineteenth century Europe (cf. La Hulpe case study in Garenne (1982)).

There exist strong indications that this mortality between the ages of 6 and 17 months in Senegal is strongly tied with diseases favoured by rain, in particular malaria. Mortality from 6 to 17 months was 3.718 times greater during the rainy season than during the dry season in 1963-1971 (see tables 96 and 97). Moreover, the ratio shows a strong correlation with the amount of rainfall: a correlation between mortality at age 6-35 months and rainfall during the period 1963-1981 yields a significant value of 0.61618, despite the existence of wide random fluctuations. This must be viewed in relation to the epidemiological environment of the region, where malaria is particularly prevalent during the winter rainy season, along with diseases characterized by diarrhoea.

TABLE 96. DEATH RATE ACCORDING TO AGE AND SEASON FOR NGAYOKHÈME, 1963-1981[a]

Age (in months)	Dry season (November-July)	Wet season (August-October)	Ratio of wet season to dry season
	(number of deaths in parentheses)		
0	.53310 (126)	.93849 (84)	1.760
1-5	.07051 (82)	.21158 (79)	3.057
6-11	.10418 (128)	.41585 (172)	3.992
12-17	.09596 (101)	.32443 (117)	3.381
18-23	.09092 (84)	.30523 (91)	3.361
24-29	.08621 (69)	.23979 (66)	2.781
30-35	.08193 (59)	.17279 (40)	2.109
36-59	.03543 (80)	.07313 (55)	2.064
60-119	.01024 (36)	.01029 (12)	1.005[b]

[a] Applies to children born during the survey.
[b] Not significantly different from unity.

TABLE 97. RATIO OF DEATH RATE IN RAINY SEASON TO DEATH RATE IN DRY SEASON, ACCORDING TO AGE AND PERIOD FOR NGAYOKHÈME, 1963-1981[a]

Age (in months)	Ratio of wet season/dry season mortality rates	
	1963-1971	1972-1981
	(number of deaths in parentheses)	
0	2.139 (89)	1.519 (121)
1-5	4.523 (83)	2.026 (78)
6-11	4.579 (198)	2.771 (102)
12-17	4.503 (121)	2.357 (97)
18-23	3.540 (113)	2.727 (62)
24-29	3.598 (58)	2.292 (77)
30-35	1.555 (45)	2.636 (54)
36-59	2.159 (44)	2.019 (91)
60-119	0.291 (10)	1.259 (38)
All	3.459 (761)	2.185 (720)

[a] Applies to children born during the survey.

This situation is quite different from the situation in the Indian Sub-continent, where the monsoon period is not marked by an additional mortality and the peak, as relates to deaths, occurs at the end of the dry season (Gordon, *et al.*, 1963; Becker, 1981). Malaria is now a curiosity in the Punjab (Wyon and Gordon, 1971), whereas there is room to believe that mortality at age 6 to 17 months at Ngayokhème is linked primarily to this disease. McGregor (1961) considers that malaria strikes particularly in about the fourteenth month; owing to the strong concentration of transmission during the rainy season, the child experiences its first contact with malaria at the age of 12 months on the average, for prior to age 6 months it is protected by the mother's antibodies, and after 18 months it will have been infected at least once.

The tropical rainy season is in fact a period of intense transmission of malaria, owing to the proliferation of anopheles mosquitoes. Indeed, the rains in July and August result in a rise in the underground water level, which starts once again to flow into the wells or tanks provided for that purpose. These wells are very favourable breeding places for the larval cycle of the anopheles. Anopheles densities can be as high as 700 mosquitoes per hut in certain regions during the month of October. In 1966, in an area very close to Ngayokhème, a mean density of 368 mosquitoes per hut was measured. In December-January, on the other hand, the considerable cooling-down of the temperature, the wide temperature spreads between day and night, and the lowering of the water table virtually put a stop to vector reproduction and most transmission. Babies are the most severely affected by malaria. Plasmodium indices (percentage of individuals infected) increase rapidly up to the age of 2 years, then level off until the age of 14 years, after which they fall once again. But it is only as of the age of about 5 years that the child acquires good immunological protection against malaria.

The second high-risk period: age 18-35 months. Exceptional mortality at age 18-35 months is what characterizes the age pattern of deaths at Ngayokhème. The same structure is observable in Saloum (Cantrelle and Livenais, 1980) and in the Gambia (Billewicz and McGregor, 1981). This period is in fact one of high potential risk, for it is the weaning period: at 18 months 89.5 per cent of all children are still nursing, and at 36 months only 4.7 per cent are still given the breast (see table 98). This high-mortality structure between the ages

TABLE 98. WEANING TABLE FOR CHILDREN BORN DURING THE SURVEY IN NGAYOKHÈME, 1963-1981, BOTH SEXES COMBINED

Age x (months)	Observed number of children weaned in the interval	Weaning table (based on hypothetical 1,000 births) l_x Number of children not weaned after stated number of months
0	1	1 000
1	2	999
3	7	998
6	7	995
9	30	992
12	45	976
15	95	951
18	244	895
21	370	740
24	288	491
27	134	274
30	62	161
33	25	91
36	14	46
48	1	2

of 18 and 35 months appears to be relatively independent of the diseases connected with rain. It was proportionally the same during the two periods 1963-1971 and 1972-1981, during which there was a sharp decline in rainfall; and during the dry season ($_4q_1/q_0$ = 1.700) as well as during the wet season ($_4q_1/q_0$ = 1.486); and it was relatively independent of mortality at age 6-17 months (the latter decreased 53.4 per cent from one period to the other, while the former (18 to 35 months) decreased only 24.7 per cent between 1963-1971 and 1972-1981).

The weaning period in fact represents several specific dangers. Winikoff (1982) summarizes these additional risks:

(*a*) Loss of (immunological) protection of mother's milk;

(*b*) Contamination of weaning foods;

(*c*) Unsuitable weaning foods;

(*d*) Weaning foods of inadequate nutritional quality;

(*e*) Inappropriate timing of dietary supplementation.

To all this one can add the effect of local customs. Until the time when it is weaned, an African child is often swaddled on its mother's back. This protects it and avoids contamination from the ground, in particular, which is frequent subsequently. Moreover, it is often during this period that the child is succeeded by a little brother or sister (a child is systematically weaned if its mother is pregnant), and this diminishes the amount of care that it receives from its mother.

One can attempt to estimate the impact of weaning on mortality by calculating the mortality rate for already-weaned children and those that have not yet been weaned. This is done by computing the total number of person-years lived at risk in each case.

The results are shown in table 99. For each age group, the risk of death in children who are still nursing is considerably higher than in children that have already been weaned. This suggests a selection effect: the healthiest children are probably weaned earlier. Unfortunately, the data do not permit any definitive conclusion on this point, since the information on weaning is not complete: among the 4,064 births considered, in 1,527 cases there was no information on weaning; all children that had migrated or had died before the age of 3 years for whom the information was missing were eliminated from the computations. It is probable that a survey bias is involved: mothers tend not to report weaning in the case of a child that has already died. But there is also a coding bias: information on weaning is not entered on the death card (it appears only on the weaning card). In any case, the relationship between weaning and mortality appears to be complex, and there is no evidence of any concentration of deaths just after weaning: among the 92 deaths that took place less than a year after weaning, 49 occurred during the first six months, and 34 during the first three months, which is insufficient from the statistical standpoint for proving any concentration at a threshold of 95 per cent. This is comparable to what Vimard (1981) observed in Togo: among 40 children that died after weaning, 3 died within 6 months, and 2 others at 7 and 8 months; the mean age at weaning is 20.4 months in that area of Togo.

TABLE 99. CENTRAL DEATH RATES ACCORDING TO AGE AND NURSING STATUS, NGAYOKHÈME, 1963-1981[a]

Age (in months)	Death rates for: Children still nursing	Children weaned	Ratio of nursing to weaned children[b]
	(number of deaths in parentheses)		
18-20	0.27350 (89)	.10230 (7)	2.6735
21-23	0.28371 (65)	.10175 (14)	2.7883
24-26	0.43221 (55)	.42720 (9)	10.1173
27-29	0.77651 (49)	.08887 (22)	8.7376
30-32	1.62076 (44)	.06265 (16)	25.8701
33-35	2.67618 (24)	.06044 (15)	44.2783

[a] Applies to children born during the survey.

[b] All ratios are significantly different from unity.

A custom that is fairly widespread in West Africa might interfere with this 18-35-month mortality: i.e., the custom of sending children into another family just after weaning. In general, the children stay there only a few days, but occasionally they are entrusted to them for lengthy periods. Among the 3-to-4-year-old resident children in 1981, 5.6 per cent resided in a compound that was not that of their mother. The survey does not follow up on children who leave the area after a separation. Nevertheless, among the children who died in the survey area one can estimate the portion who were not living with their mothers: it was 8.76 per cent among those that died as opposed to 5.61 per cent for residents at age 3 to 4 years, and 8 per cent at age 5 to 9 years as opposed to 9.50 per cent for residents (see table 100). If the children entrusted to other families had a higher death rate than the others, the ratios would have been inverted at 5-9.

TABLE 100. PROPORTION OF CHILDREN NOT LIVING WITH THEIR MOTHERS, ACCORDING TO SURVIVAL STATUS IN 1981, NGAYOKHÈME[a]

Age (in years)	Proportion not living with mother: Surviving	Died	Ratio of dead to surviving[b]
	(number of deaths in parentheses)		
0-2	.00499 (601)	.02939 (1 293)	1.684
3-4	.05607 (321)	.08759 (137)	1.250
5-9	.09503 (463)	.08000 (50)	.732
10-14	.19008 (363)	.27273 (11)	1.354

[a] Applies to children born during the survey.

[b] No ratios are significantly different from unity.

Discussion: the age pattern of mortality

Thus, there are no simple mechanisms with which to explain this exceptional mortality at age 18-35 months. This is indeed the weaning period, but neither mortality just after nursing is discontinued nor the mortality of children who are farmed out appears to be responsible for this phenomenon. Billewicz and McGregor (1981) failed to find any disease that might account for a mortality peak at these ages; the children of Keneba die of the same diseases as other children, with one particular feature: a high incidence of malaria and diarrhoea. It is not to be ruled out, however, that deaths due to diarrhoea may be caused by agents that are specific to the region. It is also conceivable that this excess mortality is due to a food deficiency. McGregor (1967) finds, however, that the 80 Keneba children born between 1949 and 1953 that died were not inferior in weight or height to those that survived, at the time of the previous annual visit. If mortality between the ages of 18 and 35 months were determined by nutrition, then the opposite would have been found, except, perhaps, if what were involved were nutrition between the time of weaning and death (a period equalling, on the average, approximately one year in this age group, inasmuch as the mean age at weaning is 24 months).

Decrease in mortality at age 6 to 35 months. The reasons for the decline in mortality between 6 and 35 months are not clear. It has been noted above that this decline shows a strong correlation with the decrease in rain. A regression on mortality trends as a function of rainfall suggests that 57 per cent of the decline in mortality can be correlated with the reduction in the amount of rain. Even though the results are relatively unstable owing to the small numbers involved, it does seem possible that the decrease in precipitation may in itself have had an impact on mortality.

The period of drought in the Sahel from 1972 to 1974 is the most typical example. This period was accompanied by a considerable drop in millet and ground-nut production, and hence both in food availability and peasant income. Nevertheless, the population of Sine did receive government and foreign aid during this period; unfortunately, no precise data could be collected on this aid.

Yet the combined effect of decreased rainfall and food aid was an appreciable 15 per cent reduction in mortality for ages 0 to 5 years in 1972-1974 compared with the mean 1963-1971 level. On the basis of the regression mentioned above, this decline might be explained entirely in terms of the drop in rainfall. It is more than likely, however, that this decline in mortality was the result of complex interactions: less exposure to environmental risks, due to the small amount of rainfall; decrease in income and in food availability; and aid provided for peasants.

Mortality continued to fall after the drought period, despite year-to-year fluctuations. Even if the lower mean precipitation did play a role, it would seem that there were other causes that accounted for the decline in mortality, at least in part.

The availability of health care did not change before 1980, when the start-up of primary health care took place. On the basis of information obtained from villagers, it does not seem that there were any major vaccination campaigns outside of the vaccinations against measles recorded in the survey (1966, 1968, 1981), apparent smallpox vaccination in the early 1970s and vaccination against cholera in 1971 or 1972. The only prophylactic campaign that might have had a significant impact on the health of the population was malaria prevention.

The *arrondissement* of Niakhar was in fact the site of multiple attempts to fight malaria. As early as 1957 it was part of the Thiès pilot area (sub-area E) and received household spraying of DDT during the dry season every year from 1957 to 1961. In 1966 it was part of ZOROP, an operational research zone in which chloroquine tablets were distributed for therapeutic purposes to any person visiting a dispensary for malaria. At that time Niakhar was included in the Fatik pilot CM, which also had the task of distributing chloroquine for therapeutic purposes (single 600 milligram dose). In 1972 13 villages in the Niakhar *arrondissement* were selected for a longitudinal study of the effect of chemotherapy and chemoprophylaxis on children aged 0 to 5 years, but the results were apparently not published. Since 1963, finally, the *arrondissement*'s co-operatives have been receiving chloroquine for prevention for all children aged 0 to 14 years. However, the coverage of these different actions is not known. It is possible that the campaign conducted in 1972 may have had an important effect on children. It does not seem, in any case, that the actions carried out in the 1960s had any effect on child mortality, and it is hard to believe that chloroquine distributions after 1973 had a greater effect than before, when the number of tablets distributed was continually decreasing.

It is also possible that hygienic practices may have changed during the 1970s. In 1973 the Toucar nurse went through the villages explaining the dangers of faeces and the utility of latrines. Certain families built them and still use them. In school, the elementary rules of hygiene were explained to children, and they were followed in certain cases. There were also a few trial distributions of foodstuffs: sardines for children, distributed when a blood specimen was taken for a nutritional survey, and foods (rice, millet) to bridge the gap when the season was bad (5 kilograms of millet per person in 1973). Aside from the recent primary-health-care developments, however, it would appear that only malaria prevention could have had a significant impact on mortality. Perhaps the creation of latrines also reduced diarrhoeal diseases, but the effect of these is not clear.

Use of the symptoms and causes of death declared by families. The survey does not provide any causes of death analysed by a physician. However, for each death the investigators note the symptoms and causes of death as stated by the family. Even if it is impossible to establish any parallel between these declarations and the actual causes of death, one can hypothesize that these declarations are consistent and that any change in the pattern of deaths according to symptom is an indication of change in the pattern of the actual causes of death.

A study of the causes and symptoms stated by families shows that between the ages of 6 months and 35 months the commonest causes are diarrhoea, malaria and fevers, respiratory diseases (defined by cough) and measles (see table 101). Diarrhoea is a precise symptom

TABLE 101. DEATHS ACCORDING TO AGE, CAUSE AND PERIOD IN NGAYOKHÈME, 1963-1981[a]

	1963-1971		*1972-1981*	
	6-17 months	*18-35 months*	*6-17 months*	*18-35 months*
Diarrhoea	52	69	32	43
Fever and Malaria	144	73	39	28
Respiratory diseases	36	16	22	11
Measles	14	11	16	37
Other diseases	36	23	20	26
Not specified	37	24	70	48
TOTAL	319	216	199	193

[a] Applies to children born during the survey.

that may be the consequence of numerous infections and lead to dehydration of the child, resulting in death. It may be the ultimate stage of a period of illness having an altogether different cause; but it can also involve a single, sudden infection causing death. The problem of considering diarrhoea a cause of death is quite general and applies just as well when it is doctors who make the diagnosis (Preston, 1976). Fevers and malaria are also symptoms that are clearly recognized by the population; it is out of the question to consider that malaria is involved in each case, for numerous infectious diseases can bring on febrile states similar to those of malaria. Among patients seeking medical attention for malaria in the region's dispensaries in 1966, only two thirds showed positive thick-blood-film findings. Nevertheless, deaths involving fever and malaria are concentrated to such an extent in the rainy season that they are probably malaria-related. Respiratory diseases including influenza, colds, sore throat and all diseases causing cough, including whooping cough, are also readily identified by the population; the interpretation in each case, however, is not so clear, inasmuch as the symptom "cough" can be associated with numerous diseases. Lastly, measles is certainly the cause of death best identified by the population. It is the disease that people fear the most, due to its very high lethality. This is a disease with a strongly epidemic character that strikes especially during the dry season; the red spots characteristic of it are easy to identify. It is likely that certain cases declared as measles are not, and that certain cases of measles go unnoticed. Gemert and others (1977) show that in 10 per cent of the cases, measles diagnoses based on clinical signs are not confirmed in blood studies. None the less, the survey data relating to measles are consistent: it comes in epidemics that can be followed; the number of cases is virtually nil after vaccination campaigns (1966, 1968). Mortality is comparable to that observed in other areas of Africa or of Senegal.

Bearing in mind these restrictions, analysis of the pattern of deaths according to age and symptom yields results that confirm the analysis of the age pattern (see table 101). In the age range 6-17 months it is malaria and fevers that dominate: this category accounted for 45.1 per cent of the deaths in the period 1963-1971 as against 19.6 per cent in the period 1972-1981, which confirms the hypothesis of a decline in mortality due to malaria. This percentage is also lower between 18 and 35 months (33.8 per cent in 1963-1971 and 14.5 per cent in 1972-1981) than between 6 and 17 months; this emphasizes the fact that mortality in the neighbourhood of the first birthday is greatly determined by malaria. Diarrhoea is the number two cause of death between the ages of 6 and 17 months and became the number one cause between 18 and 35 months in 1972-1981. The percentage of deaths from 6 to 35 months due to respiratory diseases (9.2 per cent) remained constant throughout the two periods. Mortality due to measles was strongly influenced by the 1966 and 1968 vaccination campaigns: the number of deaths attributed to this disease was appreciably lower during the first period than from 1972 to 1981, during which time practically no protection was provided. In a multiple-decrement life table for surviving children, where a child "leaves" the table when he is vaccinated or when he contracts measles (whichever comes first), about 42 per cent are vaccinated prior to any case of measles (see table 102). This figure results from a very high average age for measles (4.51 years) as opposed to a much lower age at vaccination (2.89 years) (table 102). This is of considerable importance for the efficacy of vaccination: two vaccinations spaced two years apart during the 18 survey years protected nearly one half the children exposed to the risk among those children born since the beginning of the survey, or in other words, since December 1962.

Analysis of the causes and symptoms of death declared by the family does not afford a clear idea of the

TABLE 102. MULTIPLE DECREMENT TABLE OF VACCINATION AND MEASLES RISKS, NGAYOKHÈME, 1963-1981[a]

		Computations (for 1,000 births in the table)					
		Males			*Females*		
Age x (year)	*Observed total cases of measles + vaccination*	*Survivors (never had measles, never vaccinated)*	*Children who caught measles during the interval*	*Children vaccinated in the interval*	*Survivors (never had measles, never vaccinated)*	*Children who caught measles during the interval*	*Children vaccinated in the interval*
0	251	1 000	37	65	1 000	58	52
1	341	897	88	114	889	71	113
2	254	695	84	87	704	87	101
3	144	524	53	69	517	80	49
4	127	401	56	39	392	88	51
5	85	306	62	16	253	63	18
6	72	228	57	6	172	54	14
7	51	165	46	10	104	35	10
8	34	110	38	8	59	18	0
9	26	65	20	4	41	17	5
10-14	34	41	32	9	18	15	3
TOTAL	1 419	1 000	573	426	1 000	587	412
Average age:			4.787	2.912		4.235	2.858
Number of cases:			(374)	(324)		(404)	(317)

[a] Applies to children born during the survey.

local pathology. However, it does enable one to confirm the analysis of changes in mortality observed over the two periods. What is more, an analysis of measles, a clearly stated cause, gives an idea of the role played by this disease in infant/child mortality and makes it possible to measure the impact of vaccinations on mortality due to measles.

Environmental factors and differences in mortality according to sex

The tables of mortality according to sex (tables 103 and 104) show that boys and girls both have the same probability of survival between age 0 and 5 years. This phenomenon deserves to be emphasized, for it is common in tropical areas with high mortality rates for girls to have a higher mortality than boys. This is the case in India (Wyon and Gordon, 1971) and Bangladesh (Chen and others, 1980 and 1981), where it is clear that young girls receive less food and less care than boys.

TABLE 103. DEATH RATE ACCORDING TO AGE AND SEX IN NGAYOKHÈME, 1963-1981[a]

Age (in months)	Females (number of deaths in parentheses)	Males	Ratio of female to male mortality[b]
0	.91605 (117)	.75657 (93)	1.211
1-5	.09756 (76)	.11330 (85)	0.861
6-17	.17086 (268)	.16815 (250)	.016
18-35	.11642 (196)	.13682 (213)	0.851
36-59	.04627 (72)	.04332 (68)	1.068

[a] Applies to children born during the survey.
[b] None are significantly different from unity.

TABLE 104. DEATH RATE UNDER AGE 5 BY CAUSE OF DEATH IN NGAYOKHÈME, 1963-1981[a]

Cause	Females (number of deaths in parentheses)	Males	F/M
Diarrhoea	.01999 (115)	.02381 (129)	.840[b]
Respiratory diseases	.00852 (49)	.01274 (69)	.669
Fever and malaria	.03146 (181)	.03267 (117)	.963[b]
Measles	.01078 (62)	.00757 (41)	1.424
Other	.02729 (157)	.02787 (151)	.979[b]
Not specified	.02868 (165)	.02529 (137)	1.134[b]

NOTE: Causes of death are defined by the symptoms stated by the family in the survey. Respiratory diseases include: cough, tuberculosis, chest pain, colds, influenza, whooping cough and difficulty in breathing. Fever and malaria include: malaria, high body temperature, splenomegaly, headache, fever and chills.
[a] Applies to children born during the survey.
[b] Ratios not significantly different from unity.

There is no sign that girls and boys are treated differently in Sine. The mean age of weaning is the same; the percentages of children vaccinated against measles and the ages at vaccination are the same (table 102); there is no evidence of any under-recording of girl deaths as compared with boy deaths. This supports the notion that, among high-mortality populations, whenever there is no difference in the way the children of the two sexes are treated, there is no sex difference in mortality.

However, when mortality is broken down according to the cause of symptom stated by the family, one finds that there is a higher mortality owing to measles among girls, while boys show a higher mortality due to respiratory diseases, and perhaps due to diarrhoea, although the differences are not significant (table 104).

There is no clear-cut explanation of this difference in mortality according to cause. It is possible that the different life-styles of boys and girls have an impact on their exposure to risk. After weaning, in fact, the two sexes have separate lives. The boys go to the fields to watch the flocks, while the girls accompany their mothers to the well or stay in the compound. It is possible that boys are in this way more exposed to respiratory diseases, transported by the wind, and more susceptible owing to temperature changes, but at the same time less exposed to contagious diseases that require close contact. Indeed, the mean age at which measles occurs in girls (4.24 years) is one-half year lower than in boys (4.79), which confirms that exposure to the risk probably differs between the two. This difference must have repercussions for mortality, for the younger the age of exposure (after 6 months), the higher the risk of death. Girls have a higher measles mortality rate than boys, and a lethality rate that is also higher (see table 105).

It appears that this phenomenon of a higher mortality due to measles in girls is not exceptional: in all the developing countries listed in the World Health Organization's *World Health Statistics* (1978), girls also have either a higher mortality due to measles or a higher percentage of deaths from age 1 to 4 years due to measles (see tables 106 and 107).

One might have thought that there was a difference in nutritional state between boys and girls. Here again,

TABLE 105. DIFFERENCES IN DEATH RATE DUE TO MEASLES, ACCORDING TO SEX, BETWEEN THE AGES OF 0 AND 14 YEARS, NGAYOKHÈME, 1963-1981[a]

	Females (number of deaths in parentheses)	Males	F/M
Death rate	.00843 (69)	.00554 (43)	1.522
Proportion of deaths due to measles	.09115 (69)	.05850 (43)	1.558
Case-fatality rate	.16390 (69)	.10804 (43)	1.517
Mean age at which measles occurs (if not vaccinated)	3.6816 (421)	4.0076 (398)	.9187
Probability of catching measles from age 0 to 15 years if not vaccinated	.58737(404)	.57385(374)	1.024[b]

[a] Applies to children born during the survey.
[b] Not significantly different from unity.

TABLE 106. MORTALITY DUE TO MEASLES (PER 100,000) AT AGE 1-4 YEARS, ACCORDING TO COUNTRY AND SEX

Country	Females (number of deaths in parentheses)	Males
Chile, 1975	6.5 (38)	5.0 (56)
Dominican Republic, 1975	21.1 (17)	15.1 (25)
Egypt, 1973	15.2 (66)	11.8 (78)
El Salvador, 1974	2.8 (7)	1.9 (9)
Honduras, 1975	37.6 (22)	37.3 (29)
Japan, 1976	2.0 (37)	1.7 (38)
Venezuela, 1975	28.5 (109)	27.8 (108)
Yugoslavia, 1975	5.5 (47)	3.5 (142)

Source: World Health Organization, *World Health Statistics*, 1978, table 7.

TABLE 107. PERCENTAGE OF DEATHS AT AGES 1 TO 4 YEARS DUE TO MEASLES (PER 1,000), ACCORDING TO COUNTRY AND SEX

Country	Females (number of deaths in parentheses)		Males	
Colombia, 1974	50.2	(478)	47.3	(471)
Guatemala, 1975	152.4	(1 429)	146.6	(1 380)
Jordan, 1975	75.3	(22)	34.4	(11)
Kuwait, 1975	120.0	(18)	62.4	(10)
Uruguay, 1975	157.9	(27)	128.8	(21)

Source: World Health Organization, *World Health Statistics*, 1978, table 8.

there is not, it would seem, any difference in treatment according to sex, girls and boys both eating around the same dish. Yet it is possible that boys, being more aggressive, obtain a larger share of millet or rice. However, if this were the case, mortality among girls would be higher not only for measles, which is synergistic with malnutrition, but also for diarrhoea (Rowland, 1979), which is not the case. One can thus conclude that the differences in mortality according to sex are apparently explainable rather in terms of differences in exposure to risk.

Adult mortality

Adult mortality is not measured with as much precision as child mortality, owing to the error in the recording of adult ages. However, the tables of mortality (see table 108) according to sex for the period 1963-1981 appear to be compatible with the known patterns, though any comparison is difficult because of the small numbers involved and the errors concerning age.

It has already been noted that the expectation of life beyond 10 years did not change between the two periods. Mortality among women appears to be lower after 50 years of age: $e_{50} = 25.3$, as compared with 20.8 for men (significant at a 95 per cent level). Mortality between the ages of 15 and 50 years, on the other hand, is virtually the same for both sexes: ${}_{35}q_{15} = 0.25185$ for women and 0.24662 for men (the difference is not significant).

TABLE 108. LIFE TABLE FOR NGAYOKHÈME, 1963-1981, ALL RESIDENTS, BY SEX

Age at beginning of interval (years)	Males: Number of deaths observed	$_nq_x$	l_x	$_nd_x$	e(x)
0	340	.181	1 000	181	33.5
1	486	.305	819	249	39.8
5	63	.055	569	31	52.6
10	31	.028	538	15	50.5
15	19	.021	523	11	46.9
20	14	.021	512	11	42.9
25	17	.034	501	17	38.7
30	21	.048	484	23	35.0
35	22	.057	461	26	31.7
40	13	.038	435	17	28.4
45	17	.057	418	24	24.4
50	24	.091	394	36	20.8
55	23	.105	358	38	17.6
60	34	.182	321	58	14.3
65	42	.267	262	70	11.9
70	41	.325	192	62	10.3
75	97	1.000	130	130	8.9

Age at beginning of interval (years)	Females: Number of deaths observed	$_nq_x$	l_x	$_nd_x$	e(x)
0	357	.183	1 000	183	35.7
1	492	.291	817	238	42.6
5	65	.054	579	31	55.6
10	23	.022	548	12	53.7
15	18	.021	535	11	49.8
20	31	.047	524	25	45.8
25	22	.038	500	19	42.9
30	16	.029	481	14	39.5
35	22	.044	467	21	35.7
40	24	.056	446	25	32.7
45	16	.048	421	20	29.0
50	19	.059	401	24	25.3
55	25	.093	377	35	21.7
60	24	.104	342	36	18.6
65	24	.116	307	38	15.4
70	28	.183	268	49	12.0
75	100	1.000	219	219	9.5

Conclusions

The Ngayokhème case study provides a number of precise observations on the levels and the factors influencing mortality in rural Senegal. In the first place, this annually updated population follow-up survey makes it possible to estimate with great precision the very high level of mortality, characterized by a low expectation of life at birth (34.6 for the period 1963-1981), very high infant/child mortality ($q(5) = 0.42571$), and fairly high adult mortality ($e_{10} = 52.1$).

Because of the high degree of precision regarding children's ages, the age structure of mortality in the area between the ages of 0 and 5 years is known very precisely. This structure is similar to known patterns for tropical areas in that there is a high mortality rate at ages 6 to 18 months. But most notable is an exceptionally high death rate at ages 18 to 35 months, which seems to be characteristic of this particular region of the world.

Based on yearly and seasonal variations, one can appreciate the effect of environment on mortality. In this connection, the amount of rainfall appears to be one of the possible determinants of infant and child mortality, particularly between the ages of 6 and 17 months. It appears, in fact, that the excess of mortality at this age is essentially malaria-related.

Analysis of the second high-risk period (18 to 35 months) suggests a relationship between the end of nursing and an increased mortality risk. Nevertheless, there is no simple relationship to be found between the period immediately following weaning and mortality. The direct effect is perhaps masked by weaning selection, according to which the healthier children are weaned earlier.

The causes and symptoms of death declared by the family appear to be a useful tool for grasping the real causes of mortality. Fever and malaria are observed to predominate at ages 6 to 17 months and during the wet season. Diarrhoea strongly affects mortality from 6 to 35 months; it becomes the principal cause of death at ages 18 to 35 months during the 1972-1981 period, which witnessed a decline in the death rate due to malaria.

Measles is a disease that is clearly stated, even if its diagnosis is not correct in all cases; it appears as an important, though not overwhelmingly important, cause of juvenile mortality.

On the basis of the declaration of the causes and symptoms of death by the family, it is also possible to observe a differential mortality according to sex, depending upon the cause. It is found that girls have higher mortality due to measles and lower mortality due to respiratory diseases, despite the fact that their probability of survival between 0 and 5 years of age is the same as that of boys. This difference would seem to stem from greater exposure to the risk of measles for little girls.

Adult mortality shows the characteristic features of high-mortality populations: no difference according to sex between the ages of 15 and 50 years, but lower mortality among women after age 50. The results pertaining to adult mortality are certainly biased owing to errors in connection with age. It is felt, none the less, that they reflect the level of mortality fairly well.

F. Conclusions

Since independence Senegal has witnessed a period of considerable progress but also periods that were difficult from every standpoint, particularly during the years of great drought from 1972 to 1974. The country's economy was restructured somewhat, with a relative decline in ground-nut-growing and the services connected with it, and a rise in fishing. An important weather change—the decrease in rainfall—has had repercussions both on the standard of living of the population and on the epidemiological environment. Senegal is still a country of low income and weak economic growth.

During the period covered by this study (1960-1980), there was an improvement in health services and facilities. Though the infrastructure in terms of hospitals and health stations showed little development as compared with the growth of the population, there was a very definite increase in medical and para-medical personnel, as well as in drug consumption, reflecting an increase in demand. Added to this were specific operations that may have affected mortality. In the first place, the chloroquine campaign for children aged 0 to 14 years had an appreciable impact on malaria morbidity, apparently affecting adults as well. The national measles vaccination campaign probably prevented a large number of deaths due to this disease between 1968 and 1970, but the maintenance phase of this campaign after 1970 does not seem to have affected the level of mortality due to measles, which is still one of the principal causes of death in young children.

The mortality rate during the period remained very high: life expectancy in 1970 was estimated at approximately 43 years for the whole of the country. It is likely that there was a decrease in mortality during the period under study at the national level, as evidenced by two studies. The Ngayokhème area between 1963 and 1981 showed a sizeable drop in child mortality between the ages of 6 and 36 months, probably linked to a decrease in mortality due to malaria; the second case is that of the Fleuve region, where infant and child mortality as detected in the 1978 Senegal Fertility Survey appeared much lower than the mortality observed in the 1957 survey. Any study of the factors producing this drop in the national level is difficult, owing to the lack of precision regarding ages.

Mortality in Senegal exhibits a number of characteristics that distinguish it from that of other tropical countries, in particular Asian countries, having apparently similar climates.

(*a*) The pre-5-year-old age pattern of this mortality is characterized (at least in a rural environment in Sine-Saloum) by mortality that is very high starting at age 6 months and quite exceptional between the ages of 18 and 36 months.

(*b*) There is little mortality difference according to sex between the ages of 0 and 5 years. This particular feature, which is common in tropical or Mediterranean countries, differs from the case of the countries in the Indian Sub-continent, where there is a clear-cut excess of female deaths due to different treatment between boys and girls. It would seem that this is not the case here, and that this equality of mortality for both sexes is due to a very high death rate owing to infectious diseases, and in particular, to the importance of measles, a disease that apparently strikes girls to a greater extent in Senegal.

(*c*) A very large difference in mortality exists between urban and rural areas. This difference persists independently of the factors that might act as intermediaries, which could be checked, and in particular of the educational level of the parents. This phenomenon probably reflects the considerable advantage of living in an urban environment in terms of income, nutrition, hygiene and the availability of health care. The difference is more pronounced than in other countries with comparable data.

(*d*) Ecologic zones differ to a considerable extent in mortality despite the country's very flat relief. When one compares administrative regions that are equal in terms of urbanization and education, one region appears to be at a distinct disadvantage (Casamance, the region with the highest rainfall), while two regions show mortality that is comparatively low (Thiès and the Fleuve region). These are two regions that have sizeable hospital facilities and above-average income. The Fleuve region appears to have witnessed a considerable decrease in infant/child mortality since 1957. The effects of these ecologic zones are also reflected in the seasonality of deaths: the regions in the ground-nut basin show a concentration of deaths during the tropical winter season (rainy season), whereas the peripheral regions of Fleuve and Sénégal Oriental do not exhibit this phenomenon, and the regions of Cap Vert and Casamance fall between the two extremes.

(*e*) Ethnic groups are characterized by different behaviours. When one checks for urbanization, education and region, two ethnic groups are found to be high-risk groups: the Serer and the Malinke; this suggests that these two groups have nutrition and hygiene habits that are different from the other groups in Senegal.

Finally, a peculiar feature was noted during the analysis of determinants: the relatively low net effect of modern education of parents on child mortality.

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V. MORTALITY STRUCTURE IN MATLAB (BANGLADESH) AND THE EFFECT OF SELECTED HEALTH INTERVENTIONS

*S. D'Souza**

INTRODUCTION

Vital registration in Bangladesh is woefully inadequate both with regard to its coverage and accuracy. Several estimates of mortality levels have been made through a study of age structure of various censuses. However, data from the decennial censuses have serious deficiencies with regard to age reporting and completeness of enumeration. Mortality analysis in Bangladesh has also generally relied on indirect estimation procedures utilizing data that have been obtained from sample surveys. Apart from sampling errors and biases present in retrospective data, this information is unable to capture details of the rapid changes in mortality patterns that have taken place in Bangladesh over the past decade.

Against this background, the demographic surveillance system (DSS) maintained in the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)**, in Matlab Thana, assumes great importance. While the original purpose of setting up a surveillance area for vital events was linked to cholera vaccine trials, the significance of the registration data for demographic studies soon became apparent. Since 1966, the Matlab area has had continuous mortality registration and it is thus possible to trace, for example, the effects of high mortality linked to the liberation struggle of 1971 (Curlin and others, 1976) and the famine of 1974 (Chowdhury and Chen, 1977). Studies related to fertility and contraceptive intervention also utilized the data base to measure acceptance and impact (Rahman and others, 1980). This case study report on mortality has been constructed with a set of illustrative investigations recently done in the Matlab study area. A list of the Demographic Surveillance System annual reports is attached as a bibliographical appendix.

Besides the problems related to measuring rapid changes in mortality, the assessment of mortality differentials is difficult from retrospective data based on small samples. For instance, it has been inferred that several countries in South Asia have higher female mortality rates than males, since the census data sex ratio of the population analysis favoured males at all age groups (Jain, 1975). This pattern, different from that found in most developed countries and other parts of the world, has been difficult to explain from retrospective surveys, since sex-selective omissions have vitiated indirect estimation procedures as a tool to investigate sex-related mortality differentials. The Matlab data set has permitted such a study (D'Souza and Chen, 1980). It has also valuable evidence on the extent of socio-economic differentials, suggesting that mother's education could prove an important indicator for the level of mortality—the latter being inversely related to education level (D'Souza and Bhuiya, 1982).

The monitoring of the "causes of death" in rural areas is also a difficult task. Physicians are not available to assess the cause of death. As a result, even when vital registration systems are in place, the assignment of the cause of death remains questionable, since one has to depend on reporters who have not been adequately trained. The World Health Organization has recognized this problem and a serious attempt to obtain accurate cause-of-death data through lay reporters has been promoted (World Health Organization, 1978). Cause-of-death data have been collected in Matlab since the inception of the study area and will be reviewed here. However, there are serious problems with regard to the symptoms noted and the assignment of the underlying cause of death.

The availability of health services, in developing countries especially, is intimately linked to cost considerations. Within the Matlab area costs are not easy to assess because the provision of health services is related to research considerations. However, some attempts have been made to quantify the costs of deaths averted with regard to the major health inverventions undertaken by the International Centre for Diarrhoeal Disease Research, Bangladesh, mainly those related to diarrhoea. Various estimates have been given and some of these results are provided in this report, though none should be considered conclusive. The monitoring of mortality and morbidity requires an appropriate registration system. The comparative costs of maintaining the surveillance system in Matlab with those of a "small study area" in Companiganj Thana are presented.

In spite of the complexity of the development problems faced in attempting to reduce mortality, some simple strategies are readily available that can have a rapid

* Scientific Programme Head, International Centre for Diarrhoeal Disease Research, Dhaka.

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impact on infant and child mortality. Health interventions like tetanus and measles immunization can have a fairly immediate effect. The impact of a tetanus immunization (Rahman and others, 1982) programme administered in the Matlab area provides an illustrative example.

Mortality data for Bangladesh as a whole, especially in the detail available in Matlab, are non-existent. Comparisons between the Matlab area and the rest of Bangladesh will not be attempted. However, in order to relate the Matlab results to the levels and trends of mortality in the country, some information from surveys and results from indirect estimation procedures are provided. These few studies included in the report should not be considered as comprehensive either for Bangladesh or for Matlab itself, but rather as illustrative of some problems related to mortality and its estimation. They are intended to assist policy-makers in choosing those options by which mortality can be monitored and reduced in developing countries.

History of the Matlab Demographic Surveillance System

The Matlab Demographic Surveillance System (DSS) is a unique demographic resource in Asia. Beginning in 1963 the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)*, initiated a Demographic Surveillance System in selected villages within an area adjacent to Matlab Thana, Comilla District, Bangladesh. The System combined periodic censuses of the study population with continuous registration of vital events: births, deaths and migrations. In 1966, a census was conducted in the Matlab Demographic Surveillance Area (DSA) covering a population of 110,000 residing in 132 villages referred to as the old trial area. The surveillance area was doubled in 1968 with the addition of another 101 adjacent villages referred to as the new trial area. At the 1974 census, the population of the total surveillance area was 264,000 residing in 233 villages. In October 1978, the study area was reduced to 149 villages containing an estimated 1974 population of 160,000. All of these retained villages are within Matlab Thana (Becker and others, 1982). In 1982 a new census update was undertaken. The 1982 population total was approximately 180,000.

The population of the study area in 1974 was 88 per cent Muslim and 12 per cent Hindu. The average household size was six persons. Households of patrilineally related families were grouped in clusters called "baris", having a common courtyard. Landholdings were skewed, with 18 per cent of the households owning 47 per cent of the land. About 40 per cent of the males and 16 per cent of the females aged 15 and above had completed four years of schooling. About 70 per cent of the males aged 18 and above and 6 per cent of the females were classified as "economically active".

Over the past decade, the Matlab Demographic Surveillance System has generated an enormous volume of unusually reliable data. Censuses of the population are available for 1966 (old trial area) 1968 (new trial area), 1970 (old trial area) and 1974 for the entire survey area. Vital events have been registered since 1966 in the old trial area and since 1968 in the new trial area. Beginning in January 1975, the continuous registration of marital unions and dissolutions was introduced. Depending upon the census, selected socio-economic information is available on all households. During the past two years census books updated to 1982 have been prepared. A 1982 socio-economic survey of individual households has also been undertaken. The data have been computerized.

* Formerly known as Cholera Research Laboratory.

A. Levels and trends in mortality

Table 109 provides mid-year population totals for the Matlab surveillance area as well as crude birth and death rates. There have been varying areas of coverage. The figures from the period 1966-1974 refer to data from the new trial area. The data from 1974-1977 stem from both new and old area villages and begin with the 1974 census. From 1978 the data are from the reduced area of 149 villages.

Table 109. Crude birth and death rates and rates of natural increase in Matlab, 1966-1981

Year	*Mid-year population*	*Crude birth rate (per 1,000)*	*Crude death rate (per 1,000)*	*Crude rate of natural increase*
1966-1967	112 771	47.1	15.0	32.1
1967-1968	114 561	45.4	16.6	28.8
1968-1969	116 909	46.6	15.0	31.6
1969-1970	120 217	45.3	14.9	30.4
1970-1971	124 082	43.5	14.8	28.7
1971-1972	127 840	44.5	21.0	23.5
1972-1973	130 218	41.8	16.2	25.6
1973-1974	132 797	45.6	14.2	31.4
1974	263 807	42.9	16.5	26.4
1975	259 194	29.4	20.8	08.6
1976	260 381	43.3	14.8	28.5
1977	268 894	46.4	13.6	32.9
1978	173 443	34.8	13.2	21.6
1979	175 887	40.9	13.8	27.1
1980	179 290	41.2	13.0	28.2
1981	183 011	39.5	13.1	26.4

Note: The mid-year population totals relate to varying degrees of coverage. From 1974-1977, the figures include the new trial area. From 1978 onward the study area was reduced to 149 villages.

Even though the base populations are different, the size of the study area has always been large enough to ensure a minor role for random fluctuations. The variations in birth and death rates reflect conditions in the country. The crude birth rate per 1,000 has shown a steady decline from around 47 to just under 40. The low rate for 1975 of 29.4 is entirely due to conditions produced by the famine. Falling rates after 1979 are a result of a health intervention programme in the maternal and child health-family planning (MCH-FP) area of Matlab (Bhatia and others, 1980) and are discussed below.

For the period 1966-1971 the crude death rate per 1,000 was about 15. During the period 1971-1975 the crude death rate fluctuated substantially, reaching around 21 during the liberation struggle (1971) and again during the famine period (1975). In 1976 the death rate was back to normal (14.8). It has since fallen to under 14 per 1,000. The crude rate of natural increase

(RNI) has varied from about 2.5 to 3.3 per 1,000, reflecting variations in birth and death rates. Except for the low value of 8.6 per 1,000 during the famine year (1975), the effect of fertility changes on the rate of natural increase has not been substantial.

Recent review papers have attempted to assess the levels and trends in mortality in Bangladesh since the turn of the century (Economic and Social Commission for Asia and the Pacific, 1981). Estimates of the crude death rates have been based mainly on data from the decennial census. Table 110 provides estimates of crude death rates in Bangladesh since 1881. One notices from the table that, until 1951 (i.e., the period before the partition of the Indian sub-continent), the crude death rates remained generally over 40 per 1,000. During the period 1950-1965 a decline to around 20 per 1,000 was registered. This rate of decline was not maintained during the 1970s because of problems related to the cyclone (1970), to the liberation movement (1971) and to the famine of 1974-1975 and the consequent prevailing economic uncertainty over the years.

TABLE 110. CRUDE DEATH RATES, BANGLADESH, 1881-1974

Year	*Crude death rates (per 1,000 population)*
1881-1891	41.3
1891-1901	44.4
1901-1911	45.6
1911-1921	47.3
1921-1931	41.7
1931-1941	37.8
1941-1951	40.7
1951-1961	29.7
1961-1965	18.5
1961-1974	19.4

Sources: 1881-1901: Kingsley Davis, *The Population of India and Pakistan* (Princeton, University Press, 1951), p. 36; 1901-1965: *Statistical Pocketbook of Bangladesh, 1978* (Dhaka, Bangladesh Bureau of Statistics, 1978), p. 95; 1961-1974: S. D'Souza and S. Rahman, "Intercensal population growth rates of Bangladesh", *Social Action*, vol. 27 (April-June 1977).

On the basis of stable population theory and data from the 1974 census, a crude death rate of 19.4 per 1,000 has been estimated for the 1961-1971 period. The West model life tables were utilized for this estimate—the selected levels being 12.14 for males and 10.8 for females (D'Souza and Rahman, 1978).

Census data do not provide sufficiently reliable information on which to build age-specific death rates. These rates have been estimated by the use of indirect procedures using data from surveys—the population growth estimation (PGE) project (Krotki and Ahmed, 1964) and the Bangladesh Retrospective Survey of Fertility and Mortality (BRSFM) (1977). Some data from these surveys are compared in table 111 with corresponding age-specific death rates obtained from the Matlab area. From the table one notices that the Matlab data in 1975 matches the high levels of the 1974 retrospective survey data. The sex differentials in mortality noted in Matlab, where female mortality is higher than male, is not replicated in the BRSFM data. The classical U-shape of high death rates in the age group under 5 years and then at older ages beginning with the age group 50-54 years is maintained throughout.

Infant mortality rates for the Matlab area for the period 1966-1981 are provided in table 112 and figure I. Conventional rates are presented except when specifically indicated for some results in 1975 and 1976. Male infant mortality appears on the whole to be superior to female mortality. However, a review of the neonatal and post-neonatal ratio indicates that while this is true for neonatal rates (except for 1980), for the post-neonatal rates the female rates are higher.

TABLE 111. AGE-SPECIFIC DEATH RATES, 1962-1964, 1974, 1975, 1977, 1979
(*Deaths per 1,000 population*)

	Bangladesh				*Matlab*					
	PGE 1962-1964		*Retrospective survey 1974*		*CRL 1975*		*CRL 1977*		*ICDDR,B 1979*	
Age group	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*
0	161.1	127.5	179.1	160.6	165.1[a]	184.1[a]	113.3[b]	114.2[b]	118.7[b]	114.0[b]
1-4	22.6	27.4	47.5	45.4	28.8	41.3	19.5	25.2	16.1	27.6
5-9	6.8	6.3	5.6	5.4	4.9	6.8	3.4	4.6	4.5	5.2
10-14	2.1	2.6	2.9	2.9	1.5	2.0	1.0	1.3	0.8	1.1
15-19	1.9	6.8	4.0	3.9	1.9	2.8	0.9	2.8	0.7	2.5
20-24	3.2	6.6	7.4	7.3	3.1	3.9	2.2	3.1	1.9	3.0
25-29	3.1	8.8	7.7	7.6	4.7	3.7	1.8	2.5	1.5	3.1
30-34	5.4	8.3	7.6	7.6	4.6	4.5	2.9	2.6	2.4	3.9
35-39	6.2	9.8	8.3	8.3	8.6	6.9	3.5	4.7	3.2	4.8
40-44	8.1	9.5	9.6	9.7	14.8	6.0	5.0	2.5	5.1	3.6
45-49	12.0	9.7	11.9	12.0	22.3	11.7	10.8	6.7	13.1	7.5
50-54	17.0	15.5	15.2	15.5	34.9	13.7	15.2	11.4	13.1	9.3
55-59	21.3	25.8	20.5	21.0	44.5	35.9	21.8	19.0	24.6	18.1
60-64	33.4	40.3	28.7	29.6	60.9	49.2	31.9	33.7	32.6	27.0
65-69	49.9	54.8	41.2	42.9						
70-74	76.3	85.7	61.1	63.9	113.4	111.5	76.2	76.2	68.3	84.1
75 +	111.3	136.0	92.4	97.1						

Sources: F. Yusuf, "Abridged life tables for Pakistan and its provinces 1962-64", Sydney Conference Proceedings (Liège, International Union for the Scientific Study of Population, 1967), pp. 533-541; Report on the 1974 Bangladesh Retrospective Survey of Fertility and Mortality (Dhaka, 1977), pp. 89-90; Demographic Surveillance System, Matlab, vol. 6, 1979, and vol. 9, 1982.

NOTE: PGE = Population Growth Estimation.
CRL = Cholera Research Laboratory.
ICDDR,B = International Centre for Diarrhoeal Disease Research, Bangladesh.

[a] Per 1,000 related births.
[b] Per 1,000 live births of the same calendar year.

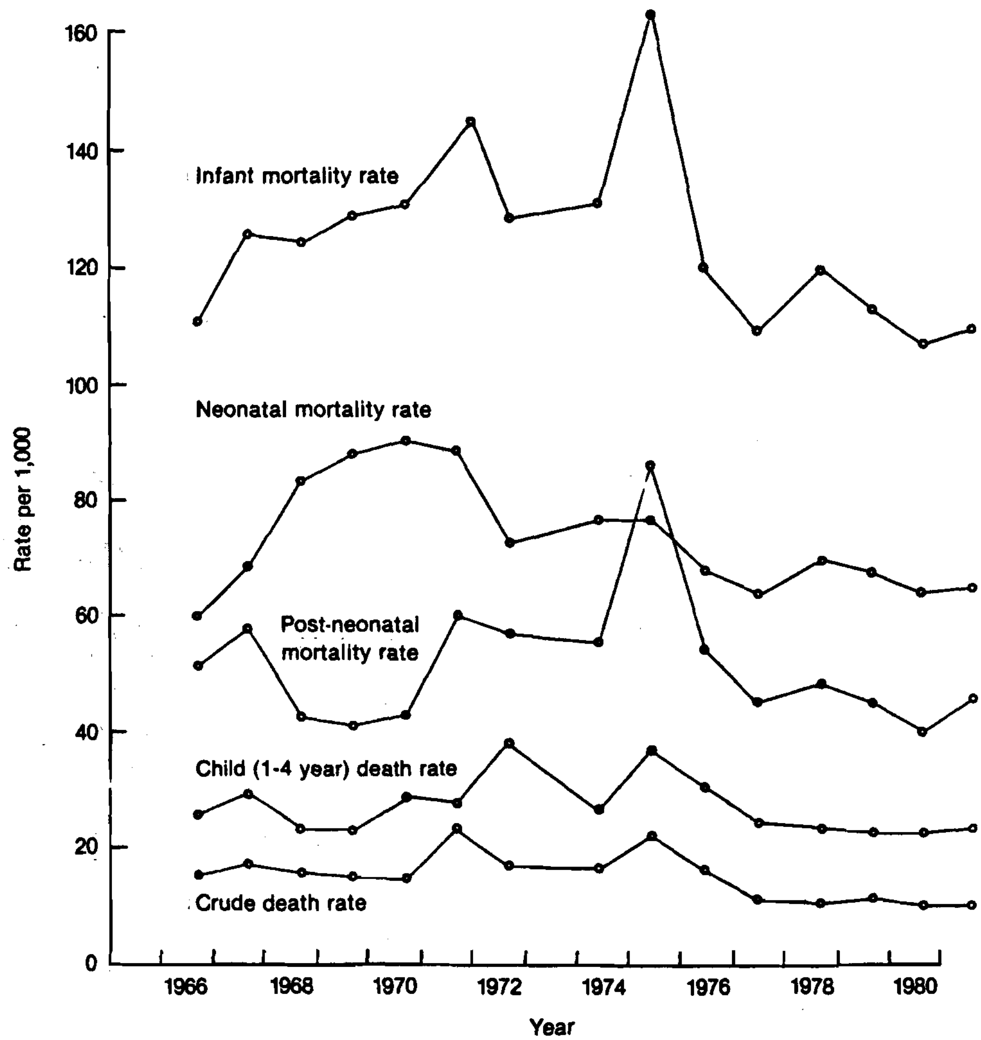
TABLE 112. NEONATAL, POST-NEONATAL AND INFANT MORTALITY RATES (PER 1,000 LIVE BIRTHS), MATLAB, 1966-1981

	Year														
	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972	1972-1973	1974	1975	1976	1977	1978	1979	1980	1981[a]
Neonatal															
Male	65.5	73.2	93.3	96.0	90.7	90.2	74.4	87.9	81.6	72.0	73.1	73.0	77.2	61.8	67.8
Female	53.6	62.3	72.5	78.7	82.1	76.0	66.7	67.8	78.1	58.1	69.4	75.3	68.5	71.6	67.3
TOTAL	59.5	67.8	83.1	87.5	89.9	83.2	70.9	78.1	79.9	65.2	71.3	74.1	73.0	66.6	67.6
Post-neonatal															
Male	52.0	53.9	36.9	41.2	37.0	63.0	53.2	54.6	98.4	33.3	40.2	43.6	41.5	28.4	37.3
Female	50.5	61.5	43.6	38.8	45.7	64.3	59.4	65.1	126.3	42.2	44.8	49.1	45.5	46.8	47.8
TOTAL	51.2	57.6	41.0	40.0	41.3	63.6	56.2	59.8	111.9	37.6	42.4	46.3	43.4	37.3	42.4
All infants															
Male	117.5	127.1	130.2	137.2	134.6	153.2	127.6	142.5	165.1[b]	113.6[b]	113.3	116.6	118.7	90.2	105.1
Female	104.1	123.8	117.8	117.4	127.9	140.2	126.1	132.9	184.1[b]	110.3[b]	114.2	124.3	114.0	118.5	115.1
TOTAL	110.7	125.4	124.1	127.6	131.3	146.8	126.8	137.9	174.3[b]	111.9[b]	113.7	120.4	116.0	103.9	110.0

[a] Cohort measure.

[b] Preliminary figures.

Figure I. Infant (neonatal and post-neonatal) mortality rate, child (1-4 years) death rate, and crude death rate in Matlab, Bangladesh, 1966-1981



From the data it would appear that, as expected, the infant mortality rates have reflected the crisis periods of the decade. The highest rates, 164.3 and 146.8, are to be found in 1971-1972 and 1975 respectively. It would appear from the data that rates varying between 110 and 140 per 1,000 have been the general pattern. The lowest values, around 110, are to be found after 1977. The value of 110.7 in 1966 may be valid but could also be a result of under-enumeration in the first year of surveillance.

Table 113 provides a breakdown of infant deaths by sex and age at death in months for the years 1979 and 1980 in Matlab. More than 60 per cent of the infant deaths took place in the neonatal period. Nearly 90 per cent of infant deaths occurred under 6 months of age. Male neonatal deaths were usually more frequent than female neonatal deaths, as shown for the year 1979. Mortality rates—both neonatal and post-neonatal—were low for males in 1980, being respectively 61.8 and 28.4 per 1,000 live births (table 113). This phenomenon is being investigated. However, the overall pattern for over 60 per cent deaths in the first month of life and about 90 per cent before six months has been maintained. It should be noted, however, that for females the percentage of infant deaths—for the post-neonatal period and particularly between 6 and 11 months—was higher than for males. This would indicate that cultural factors related to male preference may be more important at this stage than mere biological differences between the sexes.

Figure II depicts the direction and magnitude of sex differentials in mortality for children under age 5 years for 1974-1977. The ratios for female to male mortality at specific ages are plotted. Male mortality exceeded female mortality only during the neonatal period. Thereafter, female mortality exceeded male mortality by increasing amounts up to age 3 years, when female death rates were 46 to 53 per cent higher than the corresponding male rate. The ratio declined in the fourth year of life and fell further, to 1.35, for ages 5-14.

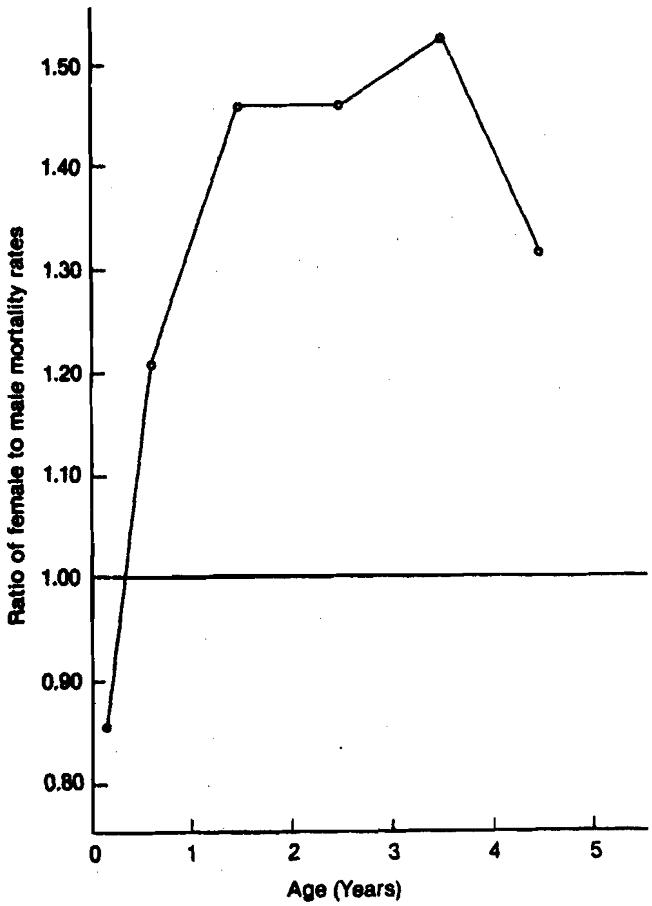
The consequences of extreme privation for sex differentials in mortality can be examined during times of crisis. D'Souza and Chen (1980) studied the percentage of "excess" female death rates in comparison with male rates during the food shortage of 1974-1975 and during the "normal" years 1975-1977. For three critical

TABLE 113. NUMBER OF INFANT DEATHS BY SEX AND AGE IN MONTHS, MATLAB, 1979 AND 1980

		Age at death in months											
Sex	*Number*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
			1979										
Male	441	287	55	27	19	12	10	9	7	2	4	3	6
Female	396	238	31	23	19	15	11	7	11	9	11	9	12
Total	837	525	86	50	38	27	21	16	18	11	15	12	18
Percentage	100	62.7	10.3	6.0	4.5	3.2	2.5	1.9	2.2	1.3	1.8	1.4	2.2
			1980										
Male	342	235	38	14	13	7	6	4	8	6	3	5	3
Female	425	257	44	29	17	13	7	12	15	8	8	9	6
Total[a]	768[a]	493[a]	82	43	30	20	13	16	23	14	11	14	9
Percentage	100	64.2	10.7	5.6	3.9	2.6	1.7	2.1	3.0	1.8	1.4	1.8	1.2

[a] Sex of one child was not indicated.

Figure II. Ratio of female to male mortality rates for children under 5 years of age, Matlab, Bangladesh, 1974-1977



Source: S. D'Souza and L. C. Chen, "Sex differentials in mortality in rural Bangladesh", *Population and Development Review*, vol. 6, No. 2 (1980).

age groups (1-12 months, 1-4 years and 5-14 years), "excess" female mortality was consistently higher during the food shortage years, suggesting that the increased mortality during disaster was disproportionately experienced by young girls.

A brief reference to the index for life expectancy at birth (e_0) may be appropriate as a conclusion to this section. From the beginning of the century till about 1941, e_0 for both sexes increased slowly from around 23.7 to 31.8. A more rapid increase was discerned during the period 1951 to 1971 – e_0 rose to around 50 in the late sixties (cf. Economic and Social Commission for Asia and the Pacific, 1981). Since then, as explained earlier, there have been fluctuations due to the unsettled conditions during the liberation struggle (1971) and the famine (1974-1975). Indirect estimates of e_0 for males and females based on the 1974 national census are 44.97 and 44.50 respectively (D'Souza and Rahman, 1978). The most recent estimates of e_0 based on Matlab 1980 data are 56.1 for males, 52.8 for females and 54.5 for both sexes (Demographic Surveillance Survey, vol. 10, 1982).

B. MORTALITY DIFFERENTIALS BY SOCIO-ECONOMIC STATUS

An appreciation of mortality conditions in Bangladesh that is an adequate basis for policy formulation requires one to attend to the existing differences in mortality among large groups. In this section some differences are considered by education, occupation, size of dwelling, ownership of cows and health practices.

The choice of particular variables is related to culture, and measurement errors are present wherever interviewers have attempted to obtain data in rural areas. The recommended socio-economic classification provided by Doring-Bradley and Johnston contains income as one of the variables (1979). Use of an ownership variable as a proxy for income has been made here, since payment by specific salaries is practically non-existent in rural Bangladesh. Mortality data for the years 1974 and 1977 are linked to the 1974 social and economic status (SES) file. Data after 1977 have not been matched to the file because of a reduction in the surveillance area in 1978 and uncertainty regarding changes in SES characteristics in the area, especially due to the famine in 1975. Bangladesh endured a period of acute shortage of food and other commodities in late 1974 and throughout 1975. The impact of this crisis has resulted in increased mortality levels for the year 1975, as well as increased migration and sale of land.

Education

In this section mortality rates of children aged 1-4 years are considered in relationship to two educational indicators: education of the household head and the highest education of any member of the family.

Table 114 presents mortality rates in early childhood by education of household head. Three levels of education have been considered: persons with no schooling or with religious education only, those who have completed one to six years of schooling and persons completing seven years or more of schooling. At all three educational levels, there is a peak in mortality rates for 1975, while 1977 rates are fairly similar to those of 1974. Considering mortality for particular years, one notices markedly lower death rates with increasing education. The ratio of mortality rates at the lowest educational level to the highest (I:III) exceeds 1.70 in each of the four years, although a slight decline in this ratio is noticed with time. Of note, too, is the fact that during the crisis year of 1975 the mortality rate at the lowest educational level was 44.6 per 1,000 (D'Souza and Bhuiya, 1982).

The higher-level groups cope better under stress conditions. Figure III shows male and female mortality rates for ages 1-4 years by education of household head. Apart from the differentials by educational level, the higher female mortality levels are clearly evident at all educational levels.

Table 115 considers mortality rates by educational attainment of the person with the highest level of schooling in the family. As before, education is measured by years of schooling. These results trace the same patterns for mortality rates as noted in table 114, the ratio I:III being even higher — 1.90 or greater.

TABLE 114. MORTALITY RATES[a] (PER 1,000) AT AGES 1-4 FOR BOTH SEXES, BY EDUCATION (YEARS OF COMPLETED SCHOOLING) OF HOUSEHOLD HEAD, MATLAB, BANGLADESH, 1974-1977

Education of household head (years of schooling)	*N[b] 1974*	*1974*	*1975*	*1976*	*1977*	*1974-1977*
I 0 (no schooling)[c]	15 406	27.3	44.6	37.3	26.0	34.5
II 1-6	9 854	21.2	33.9	27.9	19.0	25.8
III 7 +	3 569	12.0	23.3	21.4	15.4	18.1
All	28 829	23.3	38.3	32.1	22.2	29.4
Ratio I:III		2.28	1.91	1.74	1.69	1.91

[a] Under usual statistical assumptions, the differences in mortality rates at educational levels I and III are highly significant ($t = 7{,}437$, $p < .01$, d.f. = 3).
[b] N = number of persons in 1974.
[c] Or religious schooling only (*Maktab*).

TABLE 115. MORTALITY RATES[a] (PER 1,000) AT AGES 1-4 FOR BOTH SEXES, BY THE HIGHEST EDUCATION (YEARS OF SCHOOLING) IN THE FAMILY, MATLAB, BANGLADESH, 1974-1977

Highest education in the family (years of schooling)	*N[b] 1974*	*1974*	*1975*	*1976*	*1977*	*1974-1977*
I 0 (no schooling)[c]	7 577	34.7	54.3	42.3	33.9	41.9
II 1-6	13 380	24.0	36.3	32.3	21.4	28.9
III 7 +	7 872	11.5	26.2	22.3	13.4	18.5
All	28 829	23.2	38.3	32.0	22.2	29.4
Ratio I:III		3.07	2.08	1.90	2.53	

[a] Significance tests show that the difference between mortality rates at educational levels I and III are highly significant ($t = 11.976$, $p < .001$, d.f. = 3).
[b] N = number of persons in 1974.
[c] Or religious schooling only (*Maktab*).

Many people have noted that education of mothers is an important predictor of mortality levels. Due to limitations of the data, matching of deaths with educational levels of mothers can be done only for children who died between ages 1 and 3 and only for the years 1975-1977. These results are presented in table 116. As in tables 114 and 115, a relationship between increasing education and mortality levels is evident, although the ratio I:III is now as high as 5.3:1.

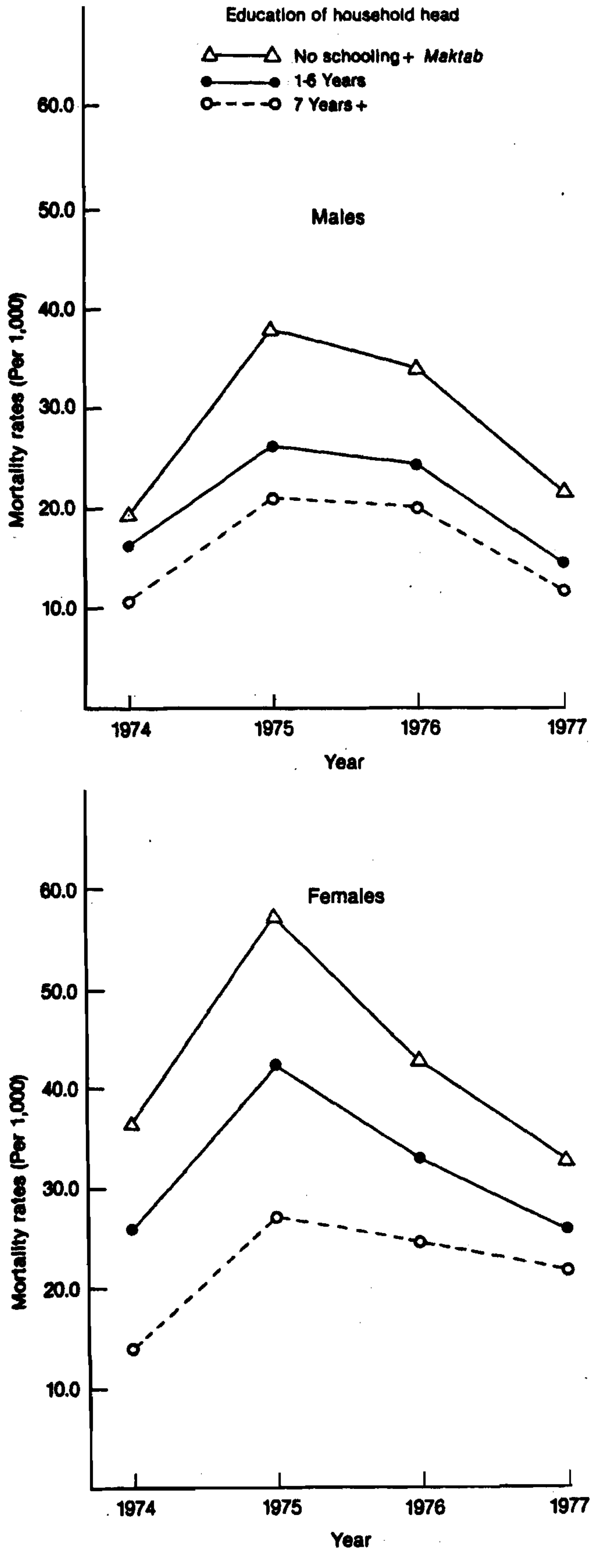
Table 117 considers mortality rates of children aged 5-14, adults 15-44, and adults 45 years and over in relation to the education of the household head. The general

TABLE 116. MORTALITY RATES[a] (PER 1,000) AT AGES 1-3 FOR BOTH SEXES, BY EDUCATION (YEARS OF SCHOOLING) OF MOTHER, FOR THE 1974 BIRTH COHORT FOLLOWED THROUGH 1977, MATLAB, BANGLADESH

Education of mother (years of schooling)	*Number of mothers, 1974*	*1975-1977*
I 0 (no schooling)[a]	21 278	33.3
II 1-6	7 439	20.2
III 7 +	853	6.3
All	29 480	29.2
Ratio I:III		5.29

[a] Or religious schooling only (*Maktab*).

Figure III. Mortality rates of children aged 1-4 years, by education of household head, 1974-1977



pattern noted for very young children is maintained: the ratio 0:7 + of mortality rates remains high for all age groups in each of the four years 1974 to 1977, although the differences appear to narrow in 1977. Statistically significant differences between the mortality rates at levels I and II are likewise noted. The differences between levels II and III are less marked. In fact, for the age group 45 + in 1976, the mortality rate for level II is 24.2, compared with 24.7 for level III. This could be due to selection effect in 1975 – the high-mortality year – when the differences in rates between groups II and III rose to 6.6, compared with 5.6 in 1974. A difference of 7.0 is again noted in 1977.

The conclusion one may draw at this stage is that educational levels are important in the understanding of differential mortality. While, for practical purposes, the education of the household head is sufficient to identify the groups more susceptible to death, mother's education may in fact be a more sensitive indicator and should be used especially where young children are concerned. Stratification by highest education of any family member might also be useful but requires more intensive data collection and tabulation.

Number of years of education of the household head or mother is relatively easy to measure. But a problem exists regarding the type of school attended. Religious schools (*Maktab*) may not have the same type of modernizing influence on health practices as secular education. Hence, it is important that allowances be made for the type of school attended.

Social and economic status (SES) data from five villages were collected early in 1981 for a pilot study. They were chosen according to criteria on size, distance from the centre and religious composition. A full-scale 1982 SES census for the entire Demographic Surveillance System area has been now undertaken on the basis of information – logistic and scientific – provided by the pilot study.

Mortality rates for 1980 for children aged 1-4 years were tabulated by mother's education (see table 118). Results similar to those recorded in table 116 were obtained, although it should be noted that the number of mothers in group III is very small.

Occupation

In the 1974 census of socio-economic status, all persons over 8 years of age were considered eligible for the labour force, and questions were thus asked regarding their economic activity. Occupational classification of heads of household in this section refers to primary occupation. Further, since the number of occupations in the census varied greatly, occupational criteria of household heads have been considered at three levels. At the lowest socio-economic level (I) are agricultural labourers, and at the highest level (III) are landowners – persons who work or live off their own land. In between, at level II, are owner/workers – persons who, while owning some land, do in fact work for others. This group includes self-employed, such as fishermen, fish vendors, boatmen and businessmen. Also included are salaried employees of industrial concerns, for example, mill workers. Clearly, some workers at level II could in fact

Table 117. Mortality rates (per 1,000) in three age groups for both sexes, by education (years of schooling) of household head, Matlab, Bangladesh, 1974-1977

Education of household head (years of schooling)	Number of persons, 1974	1974	1975	1976	1977	1974-1977
		Age group 5-14				
I 0 (no schooling)[a]	43 203	3.0	3.6	3.8	2.4	3.2
II 1-6	27 815	2.2	3.3	2.2	1.9	2.4
III 7 +	10 080	1.7	2.0	0.9	2.0	1.6
All	81 908	2.6	3.3	2.8	2.2	2.7
Ratio I:III		1.76	1.80	4.22	1.20	
		Age group 15-44				
I 0 (no schooling)[a]	60 257	2.5	4.8	2.5	2.2	3.0
II 1-6	37 944	1.9	3.3	2.2	2.1	2.4
III 7 +	13 654	1.4	3.0	1.0	1.6	1.7
All	111 855	2.2	4.0	2.2	2.1	2.6
Ratio I:III		1.79	1.60	2.50	1.38	
		Age group 45 +				
I 0 (no schooling)	23 484	22.9	50.9	28.2	23.9	31.2
II 1-6	14 711	19.8	38.8	24.2	25.2	26.9
III 7 +	5 293	14.2	32.2	24.7	18.2	22.3
All	43 488	20.8	44.5	26.4	23.7	28.7
Ratio I:III		1.61	1.58	1.14	1.31	

[a] Or religious schooling only (*Maktab*).

Table 118. Mortality rates (per 1,000) of children aged 1-4 years, by mother's education, five selected villages in Matlab, Bangladesh, 1980

Education of mother (years of schooling)	Number of mothers	1980
I 0	1 096	24.6
II 1-6	379	13.2
III 7 +	47	0.0
All	21 522	21.0

Source: Unpublished Demographic Surveillance System data, Matlab, Bangladesh.

be considered fairly well off, thus blurring the line between levels II and III.

Table 119 shows mortality rates for the three levels of occupation. As was true for education, mortality rates show declines with increasing socio-economic status. As before, rates for 1975 show the effects of crisis, with the lowest-level economic groups paying the highest price in terms of mortality. If one considers children between ages 1 and 4 years, the peak for group III appears in 1976. In the same age group, the ratios I:III remain higher than 1.9 for the four years under consideration.

Table 119. Mortality rates (per 1,000) of various age groups for both sexes, by occupation of household head, Matlab, Bangladesh, 1974-1977

Occupation of household head	Number of persons, 1974	1974	1975	1976	1977	1974-1977
		Age group 1-4				
I Agricultural labourer	4 989	35.3	57.9	43.9	31.3	42.9
II Owner/worker	20 580	21.0	35.7	29.5	21.2	27.5
III Landowner	1 113	18.0	14.5	21.7	8.8	15.9
All	26 682	23.6	38.9	31.4	22.5	29.6
Ratio I:III		1.96	3.99	2.02	3.56	
		Age group 5-14				
I Agricultural labourer	14 201	3.5	4.6	4.3	3.6	4.0
II Owner/worker	56 523	2.5	3.2	2.0	1.9	2.6
III Landowner	3 314	2.4	2.1	2.1	1.5	2.0
All	74 038	2.7	3.4	2.9	2.2	2.8
Ratio I:III		1.46	2.19	2.05	2.40	
		Age group 15-44				
I Agricultural labourer	19 962	2.8	5.7	3.6	2.4	3.6
II Owner/worker	77 807	1.8	3.5	2.0	2.1	2.4
III Landowner	4 390	2.7	3.2	1.2	1.7	2.2
All	102 159	2.0	3.8	2.3	2.3	2.7
Ratio I:III		1.04	1.78	3.00	1.41	
		Age group 45 +				
I Agricultural labourer	7 372	18.6	65.6	29.9	23.4	34.0
II Owner/worker	29 452	16.2	35.3	20.4	21.7	23.3
III Landowner	2 156	19.9	44.1	24.0	26.8	28.7
All	38 980	16.9	41.4	22.4	22.3	25.6
Ratio I:III		0.93	1.49	1.25	0.87	

Mortality patterns for children aged 5-14 and for adults aged 15-44 years are similar to those described in table 117. The ratios I:III are higher than unity for all four years. The difference between rates at levels I and III remains significant for age groups 5-14 and 15-44.

Consideration of the mortality rates of persons over age 45 shows that differences between levels I and III are less marked and are even reversed in 1974 and 1977. Agricultural labourers bear the brunt of crisis situations: mortality rates for this occupational level in 1975 reached 69.6, whereas for levels II and III they were 35.3 and 44.1. An interesting feature of this age group is that level II rates were below level III rates for all four years 1974-1977. Reasons for these differences are under study. One can speculate that a selection effect took place in earlier years and that survivors in level I and especially level II were selectively more robust as compared with those in level III. Further, group II comprised a variety of occupations, some of which may provide similar economic security after age 45 + to ownership of land. The ratios I:III were not significant.

Size of dwelling

A single aspect of housing conditions was considered – the floor area of dwellings. The 1974 census included questions on several other items, for instance, type of roof. For the purposes of this study the item mentioned provides sufficient evidence that mortality rates are inversely correlated with levels of housing conditions.

Households were divided into three groups according to the floor area of dwellings. In group II the residential area ranged from 170 to 242 square feet. Group III consisted of households occupying 243 or more square feet of residential area. Table 120 shows that levels of child mortality (ages 1-4) were nearly twice as high for group I as for group III. Patterns of mortality for the age groups 5-14, 15-44, and 45 + are similar to those indicated in tables 117 and 119.

Ownership

The 1974 census had several questions inquiring about ownership of consumer durables and producers' goods, including number of boats and cows possessed by the household. If one considers the number of cows owned and mortality rates in table 121, one notices the same pattern of socio-economic differences discussed earlier. Group I consists of households owning no cows. Group II households have one or two cows, while group III households have three or more. The mortality rates of children in Group I were well over 25 per 1,000 for the four-year period 1974-1977, whereas those for Group III were under 25 for 1975 and 1976 and around 15 per 1,000 in the years 1974 and 1977. Mortality rates for 1975 and 1976 in Group I were as high as 46.4 and 35.8 respectively. For older age groups results similar to earlier tables are noted. Figure IV shows mortality rates for children aged 1-4 by number of cows owned by household heads. Sex differentials are clearly noted even after controlling for ownership levels.

Health practices

The International Centre for Diarrhoeal Disease Research, Bangladesh, has begun studies of health practices, especially those linked to mortality due to diarrhoea and water use. Hygienic practices are related to both mortality and social status. Mortality rates for the

TABLE 120. MORTALITY RATES (PER 1,000) OF VARIOUS AGE GROUPS FOR BOTH SEXES, BY AREA OF DWELLING OF HOUSEHOLDS, MATLAB, BANGLADESH, 1974-1977

Area of dwelling (in sq. ft.)	*Number of persons, 1974*	*1974*	*1975*	*1976*	*1977*	*1974-1977*
	Age group 1-4					
I ≤169	8 575	33.1	52.7	36.9	30.5	39.0
II 170-242	6 788	24.7	39.7	33.7	26.7	31.5
III 243 +	13 466	16.4	28.9	28.5	15.7	22.7
All	28 829	23.2	38.4	32.1	22.2	29.4
Ratio I:III		2.02	1.82	1.29	1.94	
	Age group 5-14					
I ≤169	22 072	3.9	4.8	4.5	2.8	4.0
II 170-242	20 141	2.7	3.4	3.1	2.3	2.9
III 243 +	38 885	1.8	2.4	1.8	1.7	1.0
All	81 098	2.6	3.8	2.9	2.2	2.7
Ratio I:III		2.17	2.00	2.50	1.65	
	Age group 15-44					
I ≤169	30 265	3.3	5.6	2.7	2.7	3.6
II 170-242	25 830	1.8	3.9	2.3	2.1	2.5
III 243 +	55 760	1.6	3.1	2.0	1.7	2.1
All	111 855	2.2	4.0	2.3	2.1	2.6
Ratio I:III		2.66	1.81	1.35	1.59	
	Age group 45 +					
I ≤169	9 619	28.3	58.9	29.8	23.6	34.7
II 170-242	10 022	21.3	51.5	27.0	24.0	30.7
III 243 +	23 847	17.5	35.8	24.8	23.6	25.4
All	43 488	20.8	44.5	26.4	23.7	28.7
Ratio I:III		1.62	1.65	1.20	1.00	

years 1974-1977 were tabulated for users and non-users for fixed latrine facilities. For all age groups considered, mortality rates for non-users of latrines in the home were higher than those of users (see table 122). Differences tend to be much smaller than in the case of other socio-economic variables. The 1974 census had questions on water use relating, for example, to the use of tube-wells, tanks and other sources of supply. Interpretation of this data is not straightforward, since households utilize a variety of water sources.

The results presented show a clear inverse relationship between various levels of mortality and socio-economic status in the Matlab area. This inverse relationship persists for all the age groups considered: 1-4, 5-15, 15-44 and 45+ years. The criteria used for assessing socio-economic status—years of education of head of household or mother, occupation, size of dwelling, ownership of cows and health practices—were all effective for demonstrating higher mortality rates for the lower socio-economic groups.

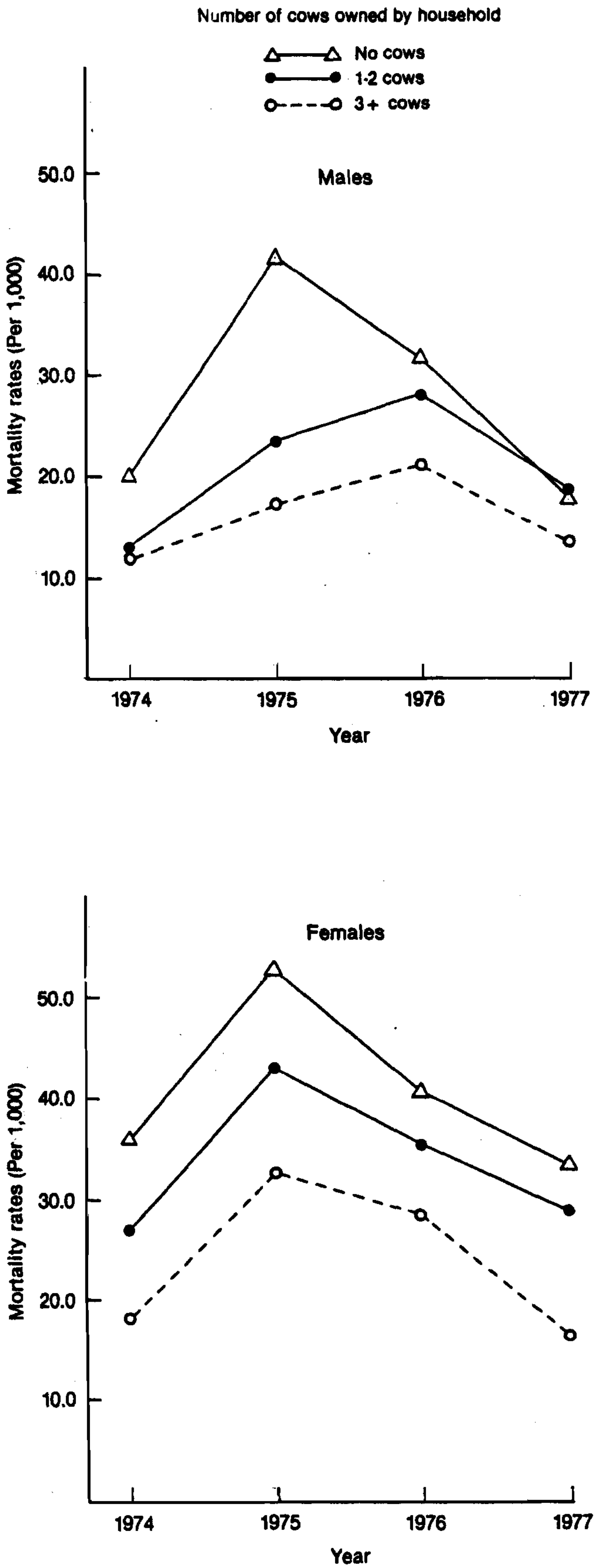
TABLE 121. MORTALITY RATES (PER 1,000) OF VARIOUS AGE GROUPS BY NUMBER OF COWS OWNED PER HOUSEHOLD, MATLAB, BANGLADESH, 1974-1977

Number of cows owned	*Number of persons, 1974*	*1974*	*1975*	*1976*	*1977*	*1974-1977*
	Age group 1-4					
I 0	15 425	27.0	46.4	35.8	25.2	34.4
II 1-2	7 290	20.6	33.1	31.2	22.8	27.2
III 3 +	6 114	15.0	24.6	24.5	14.8	19.9
All	28 829	23.2	37.8	32.1	22.2	29.4
Ratio I:III		1.86	1.89	1.46	1.70	
	Age group 5-14					
I 0	41 821	3.2	3.9	3.2	2.6	3.2
II 1-2	21 750	2.0	2.5	2.6	1.9	2.3
III 3 +	17 527	1.7	2.8	2.3	1.5	2.0
All	81 098	2.6	3.3	2.8	2.2	2.7
Ratio I:III		1.88	1.39	1.39	1.73	
	Age group 15-44					
I 0	57 820	2.7	4.8	2.5	2.2	3.0
II 1-2	28 995	1.7	3.2	2.1	2.2	2.3
III 3 +	25 040	1.6	2.9	1.8	1.5	1.9
All	111 855	2.2	4.0	2.3	2.1	2.6
Ratio I:III		1.69	1.66	1.39	1.47	
	Age group 45 +					
I 0	20 908	25.2	54.5	29.8	26.1	33.7
II 1-2	11 911	19.6	39.2	25.1	22.6	26.5
III 3 +	10 669	13.4	31.4	21.3	19.9	21.4
All	43 488	20.8	44.5	26.4	23.7	28.7
Ratio I:III		1.88	1.74	1.40	1.31	

TABLE 122. MORTALITY RATES (PER 1,000) OF VARIOUS AGE GROUPS FOR BOTH SEXES, BY USE OF LATRINE IN HOUSEHOLDS, MATLAB, BANGLADESH, 1974-1977

Use of fixed latrine	*Number of persons, 1974*	*1974*	*1975*	*1976*	*1977*	*1974-1977*
	Age group 1-4					
I No	4 976	28.9	51.0	36.5	23.1	35.6
III Yes	23 853	22.2	35.8	31.2	22.0	28.1
All	28 829	23.2	38.4	32.1	22.2	29.4
Ratio I:III		1.30	1.42	1.17	1.05	
	Age group 5-14					
I No	14 090	3.4	4.5	4.4	2.9	3.8
II Yes	67 008	2.4	3.0	2.5	2.1	2.5
All	81 098	2.6	3.3	2.9	2.2	2.7
Ratio I:III		1.42	1.50	1.76	1.38	
	Age group 15-44					
I No	19 585	2.6	5.0	2.9	2.6	3.3
II Yes	92 270	2.1	3.7	2.1	2.0	2.5
All	111 855	2.2	4.0	2.3	2.1	2.6
Ratio I:III		1.24	1.35	1.38	1.30	
	Age group 45 +					
I No	7 479	25.4	52.4	29.1	24.3	32.5
II Yes	36 009	19.8	42.8	25.9	23.5	27.9
All	43 488	20.8	44.5	26.4	23.7	28.7
Ratio I:III		1.28	1.22	1.12	1.03	

Figure IV. Mortality rates of children aged 1-4 years, by number of cows owned by the household, 1974-1977



Results from the 1975 Bangladesh Fertility Survey (BFS) confirm the findings summarized above. The survey covered the entire country, and the sample consisted of 1,519 urban and 4,626 rural households. Using the Brass type of indirect estimation procedures to analyse the information on proportions dead among children ever born at the time of the survey, Mitra (1979) also found an inverse relationship between mortality and parents' education, father's occupation and economic status. Table 123 presents estimates of child mortality by educational level of mothers.

TABLE 123. ESTIMATES OF CHILD MORTALITY BETWEEN BIRTH AND AGE X, q (X), BY EDUCATIONAL LEVEL OF MOTHERS, BANGLADESH

	Estimates of child mortality		
Educational level of mother	*q(2)*	*q(3)*	*q(5)*
Illiterate	20.4 (987)	23.5 (865)	24.0 (645)
Less than 5 years	17.8 (145)	17.4 (124)	18.6 (77)
5-8 years	13.2 (162)	12.7 (126)	15.6 (62)
9 years or more	13.4 (63)	14.4 (37)	6.2 (18)

Source: Bangladesh Fertility Survey, 1975.
NOTE: Figures in parentheses are the numbers of respondents in each category.

Similar results are obtained for the other socio-economic characteristics. Estimation of $q(2)$, $q(3)$ and $q(5)$ is generally considered to be less affected by reporting errors than that of $q(1)$. Using the estimates of $q(2)$, $q(3)$ and $q(5)$, implied estimates of $q(1)$ can be obtained from model life tables.

Clearly the variables discussed here are correlated. Persons of higher education are likely to belong to families having more possessions, larger houses and the like. In order to assess whether education would still be important after controlling for the various other parameters—occupation, area of dwelling, number of cows owned, use of fixed latrine—three-way tabulations were prepared. These are found in table 124. The inverse relationship between mortality rates and education, even controlling for other socio-economic characteristics, is quite clear from the table.

Mitra (1979), using Bangladesh Fertility Survey data, constructed a simple index of economic status—poor, middle, rich—depending on the possession of such items as radio or watch. Controlling for economic status thus defined, he found a similar inverse relationship between parents' literacy and mortality.

Apart from the development of methodological tools for mortality studies, the major importance of the results from the Matlab investigations is that large differentials in mortality levels have been documented for various socio-economic strata in a rural area of Bangladesh—the lowest strata having the highest mortality levels. The inverse relationship between education of mother and mortality rates have been strikingly shown. In the age group 1-3 years the mortality rates are over five times higher for children of mothers having no education as compared with mothers having seven or

TABLE 124. MORTALITY RATES (PER 1,000) FOR CHILDREN OF BOTH SEXES AGED 1-4 YEARS, BY EDUCATION OF HOUSEHOLD HEAD AND OTHER SOCIO-ECONOMIC VARIABLES, MATLAB, BANGLADESH, 1974-1977

Education of household head (years of schooling)	*Number of persons, 1974*	*Occupation*			
		Agricultural labourer	*Owner/ worker*	*Land-owner*	*All*
No schooling[a]	128 772	32.8	23.0	20.4	25.2
1-6 years	83 066	26.9	18.5	8.9	19.1
7 + years	30 021	9.5	13.5	10.4	13.1
TOTAL	241 859	31.2	19.9	13.5	21.7
		Area of dwelling			
		169	*170-242*	*243 +*	*All*
No schooling[a]	142 350	31.4	26.7	18.3	25.3
1-6 years	90 324	24.8	19.6	16.2	18.8
7 + years	32 596	17.0	19.6	11.5	12.9
TOTAL	265 270	28.9	23.5	16.2	21.5
		Number of cows owned			
		0	*1-2*	*3 +*	*All*
No schooling[a]	142 250	29.2	22.6	16.9	25.3
1-6 years	90 324	22.0	17.6	14.0	18.9
7 + years	32 596	14.3	13.1	10.3	13.0
TOTAL	265 270	25.3	19.6	14.8	21.5
			Use of fixed latrine		
			Yes	*No*	*All*
No schooling[a]	142 350		22.3	28.7	25.3
1-6 years	90 324		18.7	19.6	18.8
7 + years	32 596		12.6	16.0	12.9
TOTAL	265 270		20.6	26.0	21.5

NOTE: The slight differences in rates for "All" in the "Occupation" section of the table are due to the differences in number of persons. The results for "All" in the other sections are in principle identical except for rounding off differences. Deaths of a few children born before 1974 have been missed from the data tape from which the three-way table has been prepared, using computer facilities in Bangkok. The results are substantially comparable with those presented earlier in two-way tabulations.

[a] Or religious schooling only (*Maktab*).

more years of schooling. The vulnerability of the lowest socio-economic status groups to very high mortality rates during times of crisis has also been shown. Higher social and economic status (SES) groups appear to have a higher capacity to withstand the hardships arising from floods and subsequent shortage of food. The Matlab data provide one of the very few opportunities for investigating this issue.

Differentials in infant mortality rates by SES are linked to such biological factors as month of gestation, height of mother and weight of infant (Chowdhury, 1982). Preterm deliveries were common among mothers with no education. Higher neonatal death rates are found among children of mothers with no education. More studies on infant mortality need to be undertaken to separate the various confounding social and biological variables. Further studies relating birth weights and infant mortality can be undertaken in the rural setting of Matlab.

C. CAUSE OF DEATH

The Matlab death reporting system has undergone some changes over the past 15 years. As of 1966 (the first year for which the Data Management Branch has documentation) deaths were classified in 22 categories. Those categories were reduced to 9 in 1968, and the list was expanded to 27 categories in 1974. In 1980 smallpox was dropped. Some results are presented first, while details of the methods used and limitations of the cause-of-death data, including potential for improvement, are discussed in the next section.

Some results

Much valuable information has been generated by the system to date. Tabulations of deaths by causes are available in Demographic Surveillance System reports for 1974 through 1979 (see reference list); 1980 and 1981 reports will be available in the near future. Based on an analysis of the 1975-1977 data, Chen and others (1980) reported that the tetanus neonatorum death rate (per 1,000) was 37.4 in Matlab. They estimated that the infant death rate (per 1,000) due to diarrhoea was 19.6, for respiratory diseases it was 10.4, for fever, 7.3. However, the rate of infant deaths due to "other" causes as well as unknown causes was as high as 62.2 (per 1,000). The overall infant mortality rate was 142.6 per 1,000. In the case of children (aged 1-4 years) death rates (per 1,000) due to diarrhoea, 15.1 (adjusted rate), and measles, 4.5, were recorded as the most important reported rates of causes of death in the absence of health interventions. Another study from the Matlab area has provided valuable insight into the coincidence between the clinical syndrome of neonatal tetanus and the local classifications of ***alga***, ***dhanustonkar*** and ***takuria***, demonstrating that not all *alga*, *dhanustonkar* or *takuria* deaths could be attributed to neonatal tetanus (Rahman and others, 1981).

Table 125 presents data on infant and child deaths for the years 1975-1977 (D'Souza and Chen, 1980). A few important causes of death – tetanus, diarrhoeal diseases, respiratory diseases and measles – have been singled out because of their relevance and the reasonable likelihood of accurate identification. For infants, tetanus appears to account for about a quarter of all deaths. Respiratory and diarrhoeal diseases are next in importance. Sex differentials with regard to cause of death do not appear significant during infancy. Since tetanus is presumably due to unhygienic treatment of the umbilical cord during the neonatal period, the lack of a strong sex differential for this cause of death is not surprising. For the age group 1-4 years, diarrhoeal diseases, respiratory diseases and measles are the most important causes of death. Sex differentials are noted for all infectious causes of death, with female deaths being consistently higher than male deaths.

Table 126 provides reported "cause of death" of infants by sex and age at death in months for the year 1980. Tetanus accounts for more than 50 per cent of the reported infant deaths and over 70 per cent of the deaths occurring under age 1 month. Because of increased awareness of the disease, it is likely that tetanus was overreported as a cause of death in 1980. As mentioned earlier, the large majority of watery diarrhoea deaths are averted by the treatment centre. Respiratory diseases and measles are two other important reported causes. Measles deaths are first reported between 5 and 6 months of age. The occurrence of measles among children 6 months of age has been recorded by the Demographic

TABLE 125. INFANT (0-11 MONTHS) AND EARLY CHILDHOOD (1-4 YEARS) MORTALITY, BY SEX AND MAJOR CAUSES OF DEATH IN MATLAB, BANGLADESH, 1975-1977

		Infant deaths		*Child deaths*	
Cause of death	*Sex*	*Number*	*Per 1,000 live births*	*Number*	*Rate per 1,000 population*
Tetanus	Both sexes	1 174	37.42	59	0.60
	Male	599	37.26	30	0.59
	Female	575	37.59	29	0.61
Diarrhoeal diseases	Both sexes	91	2.90	153	1.55
	Male	50	3.11	67	1.32
	Female	41	2.68	86	1.80
Respiratory diseases	Both sexes	328	10.45	160	1.62
	Male	163	10.14	66	1.30
	Female	165	10.79	94	1.96
Measles	Both sexes	96	3.06	440	4.46
	Male	45	2.80	194	3.82
	Female	51	3.33	246	5.14
Others	Both sexes	2 352	74.96	1 992	20.19
	Male	1 180	73.39	824	16.24
	Female	1 172	76.62	1 168	24.39
All causes	Both sexes	4 041	128.80	2 804	28.43
	Male	2 037	126.69	1 181	23.27
	Female	2 004	131.01	1 623	33.89

TABLE 126. NUMBER OF INFANT DEATHS, BY SEX, REPORTED CAUSE OF DEATH AND AGE AT DEATH IN MONTHS, MATLAB, BANGLADESH, 1980

			Age at death in months											
Cause of death	*Percentage*	*Number of persons*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Males														
Tetanus	59.6	204	175	17	5	4	1	1	0	0	1	0	0	0
Measles	1.2	4	0	0	0	0	0	0	1	0	0	1	0	2
Diarrhoea	1.8	6	0	0	0	1	0	1	1	1	1	0	1	0
Respiratory	6.4	22	5	4	2	2	2	2	0	0	2	1	2	0
Others	31.0	106	55	17	7	6	4	2	2	7	2	1	2	1
TOTAL	100.0	342	235	38	14	13	7	6	4	8	6	3	5	3
Females														
Tetanus	50.4	214	174	21	9	3	2	0	2	2	0	1	0	0
Measles	2.6	11	0	0	0	0	0	1	1	1	2	2	2	2
Diarrhoea	3.3	14	0	0	1	1	2	1	2	3	2	0	2	0
Respiratory	7.1	30	8	7	0	6	1	0	3	2	1	1	1	0
Others	36.7	156	75	16	19	7	8	5	4	7	3	4	4	4
TOTAL	100.0	425	257	44	29	17	13	7	12	15	8	8	9	6

NOTE: The data are from the Demographic Surveillance System. Analyses and comparability of reported cause of death for various time periods is under way (S. Zimicki and S. D'Souza, "Validity of Matlab DSS cause of death reporting, 1974-1982" (in preparation).

Surveillance System. The implications for measles vaccine campaigns are important, since the vaccine is usually administered to children over 9 months of age. Further studies, with serological confirmation of measles, are under way. The large number of deaths in the "other" classification, at ages under 3 months, also require more investigation.

Causes of death have been studied in greater detail in the Companiganj Health Project than in the Matlab area. Causes of death were determined retrospectively by family interviews which were reviewed by a committee of physicians. Immediate and underlying causes of death were recorded. Where some doubts remained, a physician was sent to interview the family. As field investigators became more proficient, fewer visits by physicians were necessary—the percentage of such visits required for the years 1975, 1976, 1977 and 1978 were 78, 62, 37 and 25 per cent respectively (Chowdhury, S. A., and Khan, A. H., 1980). Table 127 shows death by sex and cause for the years 1975-1978. The most frequent causes of death were diarrhoea, malnutrition, pneumonia and birth-associated causes (prematurity, birth injury, neonatal tetanus).

If one related causes of death to landholdings, one could understand better the variations in death rates that took place over the years 1975-1978. Diarrhoea and malnutrition account for most of the observed variation in mortality over the years 1975-1978, and of differences between the various landholding groups (see figure V). Families with over three acres of land have very few deaths from birth-associated conditions. Diarrhoea deaths are highest among the poorer groups. Better sanitation among wealthier families may have played a role, though such differences as exist are not great. The drop in diarrhoea deaths among the landless from the crisis years (1975-1976) to the normal years (1977-1978) is remarkable. On this evidence, it is more likely that the difference in diarrhoea death rates between richer and poorer groups is due to better nutrition.

This section on "cause of death" provides useful information, but large areas have been undocumented. Adult mortality has to be investigated. Some studies have considered specific problems, for example maternal mortality (Chen and others, 1974). Morbidity and mortality for the age group 45 years and over remains to be investigated. A list of health problems of Bangladesh are to be found

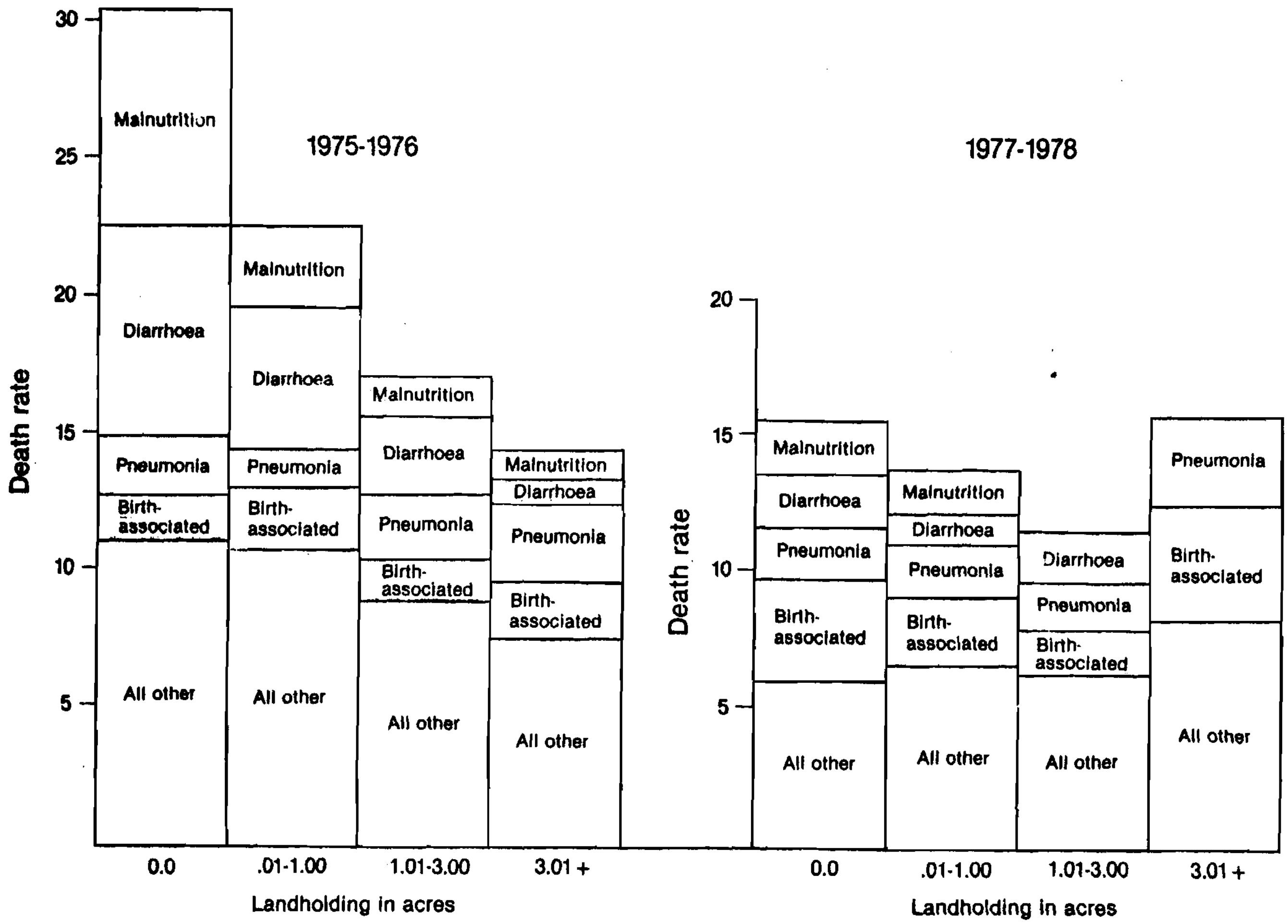
TABLE 127. CAUSES OF DEATH AT COMPANIGANJ, ACCORDING TO SEX, PERCENTAGE AND RATE PER 100,000 (CUMULATIVE 1975-1978), ALL AGES COMBINED

Causes of death	*Male*	*Female*	*Total*	*Percentage*	*Rate/100,000*
		(number)			
All causes	385	392	777	100	1 791.9
Diarrhoeal diseases	50	77	127	16.3	292.9
Malnutrition	50	52	102	13.1	235.2
Pneumonia	39	45	84	10.8	193.7
Prematurity/birth injury/asphyxia etc.	39	28	67	8.6	154.5
Senility	34	23	47	6.0	108.4
Tetanus	19	15	34	4.4	78.4
C.V.A.	17	18	35	4.5	80.7
Pulmonary T.B.	18	8	26	3.3	60.0
Fever	10	11	21	2.7	48.2
Measles	10	11	21	2.7	48.2
Drowning	10	10	20	2.6	46.1
Heart diseases	12	5	17	2.2	39.2
Chronic lung disease (not T.B.)	10	6	16	2.1	36.9
Maternal death	0	12	12	1.5	27.7
Acute abdomen/intest. obst.	6	3	9		
Cancer	5	4	9		
Injury/accident	3	5	8		
Liver disease	4	3	7		
Anaemia	2	5	7		
Skin infection/abscess	4	2	6		
Whooping cough	3	2	5		
Acute nephritis	2	3	5		
Burn	1	3	4		
Meningitis	2	2	4	10.4	186.3
Peptic ulcer	4	0	4		
Suicide/homicide	0	3	3		
Diphtheria	2	0	2		
Chicken pox	1	1	2		
Rheumatic fever	1	1	2		
Sore mouth	1	1	2		
Brain tumor	0	1	1		
Congenital deformity	1	0	1		
Others	12	6	13	2.3	41.5
Unknown	23	26	49	6.3	113.0

Source: S. A. Chowdhury and A. H. Khan, "Causes of death, Companiganj, Bangladesh, 1975-78", Dhaka Christian Commission for Development in Bangladesh, 1980.

NOTE: Denominator: 43362. Individual percentage and rates have not been calculated for frequencies less than 10.

Figure V. Death rates per 1,000 population, by landholding and cause, Companiganj, 1975-1976 and 1977-1978



Source: S. A. Chowdhury and A. H. Khan, "Causes of death, Companiganj, Bangladesh, 1975-78", Dhaka Christian Commission for Development in Bangladesh, 1980.

in the "Bangladesh Health Profile" (1977). Incidence and mortality rates quoted remain tentative in a country with a meagre vital and morbidity registration system. Furthermore, the classification of diseases and causes of death is subject to many ambiguities and pitfalls.

The problems encountered in the Matlab reporting system for cause of death can be summarized as follows: (*a*) because local perceptions of disease differ from medical models, it is insufficient simply to ask "what did this person die of?" and expect to receive directly codable information; (*b*) because the interviewers are not medically trained and therefore their own ideas of disease causation may differ, information about circumstances of death is not elicited or recorded consistently, and the level of training and supervision given has not been sufficient to overcome this; (*c*) because office workers also have varying ideas about disease and because there are no documented rules for decision when two classifications are possible, the same kind of death may be coded in two or more categories. Even if field workers and office classifiers were all fully medically qualified, misclassification would occur; it would be less frequent simply because of the longer period of standardized training and more standardized views about causal pathways.

Even as a basis for decisions about medical interventions, the classification systems currently used may be problematic because they allow deaths to be classified only as due to a single cause. Death is often multicausal, and in situations where mortality might be reduced by intervening against an antecedent cause or contributory conditions (say malnutrition, or measles in the measles-viral pneumonia progression), knowledge about these causes may be more important than knowledge about direct causes for which no intervention is feasible.

D. Health intervention and mortality

The specific role of the International Centre for Diarrhoeal Disease Research, Bangladesh, is to conduct research in diarrhoeal diseases and directly related subjects of nutrition and fertility. Thus, the mandate of the Centre is fairly restricted and the health interventions undertaken by it have, apart from diarrhoea control, concentrated on components of a maternal and child health/family planning package (Rahman and D'Souza, 1980).

At its inception, the focus of research in the Matlab area was mainly on cholera. A diarrhoea treatment centre was established and a fleet of speedboats was maintained as ambulances to transport patients to the treatment centre. Direct assessment of mortality reduction due to the treatment centre is not possible, since nearly all cases of watery diarrhoea conventionally defined as at least three liquid stools a day were saved through the system of speedboats and the clinic. Indirect estimates of "deaths averted" have been made. Assuming that 50 per cent of the cholera field cases would have died without the facilities of the treatment unit, Mosley and others (1972) concluded that the reduction in the crude death rate in the Matlab area was 9.1 per cent. Using severity of dehydration information at the treatment centre and similar assumptions, Chen (1980) assessed the reduction in the crude death rate due to the treatment centre to be about 14.2 per cent.

Between 1963 and 1974 the International Centre for Diarrhoeal Disease Research conducted five large-scale cholera vaccine trials in the Matlab area. The results showed that protection achieved was partial and short-lived (Mosley, Bart and Sommer, 1973; Curlin and others, 1975). As a result of these studies it was concluded that hospital-based therapy was more effective.

Following recent trends regarding health care, the Centre has focused its attention on community-based interventions. An evaluation of a second Centre field station at Teknaf—where transport is not provided to patients—showed the proportion visiting the treatment centre of the group of patients suffering from diarrhoea ("attendance rate") was 60 per cent for those living within two miles of the Teknaf treatment centre and 40 per cent for those living three miles away. Of reported diarrhoea patients who lived within one mile of the treatment centre, 90 per cent utilized its services.

To assess the impact of a village-based approach to diarrhoea treatment, an oral therapy field trial was set up in 1978 in the Matlab area. An 80 per cent use rate was registered within a few months of the inception of the programme. Within the study area two different compositions of oral rehydration solutions (ORS) were used. In one part, consisting of 40,000 population, packets were used based on the standard World Health Organization formula. In the second area of similar population size, locally available ingredients—salt and sugar (*lobon-gur*)—were distributed. Appropriate persons (*bari* mothers) were trained to prepare the solution at home for those who needed it. In the ORT comparison area—also consisting of about 40,000 population—no specific intervention was undertaken, though the usual services of the Matlab treatment centre were available.

Table 128 compares the distance effect on clinic attendance rates for the two years prior to the study (1977-1978) with the two study years (1979-1980). One notices that the declines in the attendance rate (1977-1978/1979-1980) for both the packet and the *lobon-gur* areas are significant for all distance strata. If one now considers the comparison area, the attendance rate decline is significant only for the 1-2 miles and 3-4 miles categories. These results would indicate that a reduction in clinic attendance has been achieved by the programme, though some diminution extraneous to the programme has resulted from lower incidence rates of diarrhoeal diseases in the study years as compared with the pre-study years, as illustrated by the comparison area (Zimicki and others, n.d.). Mortality rates due to diarrhoea have always been low in the Matlab area due to the presence of the treatment and the ambulance speedboat system. The study has shown that the introduction of home-based services by both the packet and *lobon-gur* approaches lowered clinic attendance without any obvious adverse effect on mortality appearing in vital statistics.

The components of the maternal and child health-family planning (MCH-FP) package were introduced gradually into the Matlab area from October 1977. Initially, only family planning services were offered, but as the programme got under way other selected inputs—immunization, oral therapy and nutrition education—were introduced. These inputs were introduced in half the Matlab study zone (treatment area), while in the other half (comparison area) there were no specific inputs besides overall diarrhoeal services through the ambulance system and oral rehydration solutions. Table 129 shows a striking difference between the treatment and comparison areas with regard to the crude birth rate. A five-point difference in 1978 increased to over 8 points in 1980-1981, and was as large as 12 points in 1979. The crude death rate for the treatment area has been brought under 12 per 1,000, but remains over 14 per 1,000 for the comparison area.

Table 130 considers neonatal and post-neonatal rates for the four years 1978-1981 by treatment and comparison area. For the MCH-FP area, one notices that the years 1980-1981 show substantially lower rates than the corresponding rates for the years 1978-1979. Thus the

TABLE 128. CLINIC ATTENDANCE RATES PER 1,000 IN 1977-1978 AND 1979-1980, BY DISTANCE, STUDY AND COMPARISON AREAS

Estimated distance (in miles)	*Study area*						*Comparison area*		
	Packet rate			*Lobon-gur rate*			*Rate*		
	1977-1978	*1979-1980*	*RR*[a]	*1977-1978*	*1979-1980*	*RR*	*1977-1978*	*1979-1980*	*RR*
<1	70.6	38.1	1.9[b]	69.6	39.4	1.8[b]	58.4	57.0	1.0
1-2	40.4	22.8	1.8[b]	40.3	26.1	1.5[b]	39.2	28.6	1.4[b]
3-4	38.1	22.2	1.7[b]	27.5	16.3	1.7[b]	24.1	17.5	1.4[b]
5-6	20.0	13.9	1.4[b]	25.6	12.0	2.1[b]	27.1	23.1	1.2
7-8	17.1	14.6	1.2	-	-	-	-	-	-
Crude	32.4	19.8	1.6[b]	31.2	18.9	1.7[b]	36.2	26.8	1.4[b]

Source: Zimicki and others, "A field trial of home-based oral rehydration solution in rural Bangladesh", in preparation.

[a] Rate ratio 1977-1978/1979-1980.
[b] $p < .005$.

neonatal mortality rates per 1,000 were 59.3 and 65.8 in 1980 and 1981 as against 69.0 and 70.9 in 1978 and 1979, respectively. The post-neonatal rates were also lower in the years 1980 and 1981 as compared with the years 1978 and 1979. The very low 1980 male neonatal and post-neonatal mortality rates in the MCH-FP area are under investigation. A decline over the four years 1978 through 1981 also occurred in the comparison area, with neonatal rates higher than the corresponding MCH-FP area rates. With regard to the post-neonatal rates in the comparison area, while male children had similarly declining rates as in the treatment area, the mortality rates for female children showed little decline over the four years. The difference between the MCH-FP and comparison area female post-neonatal rates was 1.5 in 1978, whereas in 1981 it rose to 16.5.

An examination of table 131 shows that, for children aged 1-4 years, mortality rates in the MCH-FP area were

TABLE 129. CRUDE BIRTH AND DEATH RATES AND RATES OF NATURAL INCREASE FOR THE MATERNAL AND CHILD HEALTH-FAMILY PLANNING AND COMPARISON AREAS IN MATLAB, 1978-1981

Area	*Year*	*Mid-year population*	*Crude birth rate (per 1,000)*	*Crude death rate (per 1,000)*	*Crude rate of natural increase*
MCH-FP	1978	88 925	32.1	12.5	19.6
	1979	89 574	34.9	12.1	22.8
	1980	91 010	37.1	11.3	25.8
	1981	92 634	35.3	11.9	23.4
Comparison	1978	84 518	37.8	13.8	24.0
	1979	86 313	47.0	15.6	31.4
	1980	88 280	45.5	14.8	30.7
	1981	90 377	43.8	14.4	29.4

TABLE 130. NEONATAL AND POST-NEONATAL MORTALITY RATES (PER 1,000 LIVE BIRTHS), MATLAB, 1978-1981, FOR THE MATERNAL AND CHILD HEALTH-FAMILY PLANNING AND COMPARISON AREAS

		MCH-FP		*Comparison*	
Year	*Sex*	*Neonatal*	*Post-neonatal*	*Neonatal*	*Post-neonatal*
1978	Male	70.9	42.7	75.0	44.4
	Female	67.0	48.5	82.5	49.6
	Both	69.0	45.5	78.7	47.0
1979	Male	71.3	40.5	81.9	42.1
	Female	70.6	46.6	66.9	44.6
	Both	70.9	43.5	74.6	43.3
1980	Male	51.0	23.2	70.0	32.6
	Female	67.2	42.4	75.6	50.8
	Both	59.3	32.6	72.7	41.3
1981	Male	67.4	36.6	68.2	37.8
	Female	64.2	38.8	69.8	55.3
	Both	65.8	37.7	69.0	46.3

TABLE 131. AGE/SEX-SPECIFIC DEATH RATES (PER 1,000) FOR CHILDREN UNDER 5 YEARS OF AGE, FOR THE MATERNAL AND CHILD HEALTH-FAMILY PLANNING AND COMPARISON AREAS, MATLAB, 1978-1981

Area	*Age group (years)*	*Sex*	*1978*	*1979*	*1980*	*1981*
All	< 1[a]	M	116.6	118.7	91.0	105.1
		F	124.3	114.0	120.1	115.1
		T	120.4	116.4	105.1	110.1
	1-4	M	16.9	16.1	16.1	16.6
		F	28.2	27.6	27.8	28.7
		T	22.3	21.6	21.7	21.6
MCH-FP	< 1[a]	M	113.6	111.8	74.8	104.0
		F	115.5	117.3	109.6	103.0
		T	114.5	114.4	91.9	103.5
	1-4	M	17.3	13.7	14.5	11.7
		F	28.0	20.8	22.9	26.7
		T	22.5	17.1	18.6	18.9
Comparison	< 1[a]	M	119.4	124.0	102.6	106.0
		F	132.0	111.4	126.4	125.1
		T	125.8	118.0	114.0	115.3
	1-4	M	16.3	18.5	18.5	20.0
		F	28.3	34.5	32.9	29.7
		T	22.1	26.2	25.4	24.7

[a] Per 1,000 live births.

lower (around 10 per 1,000) than in the comparison area (around 25 per 1,000). How much of the difference is attributable to the programme and how much to other differences has not been precisely determined. The higher female rates in both areas should be noted. One would thus legitimately conclude that while the presence of health services may have brought about a lowering of mortality rates, the use of such services remains subject to the various cultural and other biases that may exist within the population.

Family planning

There were many components in the MCH-FP programme and it is difficult to assess their separate effects on mortality. In this section we consider the effects of the family planning component *per se* (from Chen and others, 1983). In order for family planning to exert an effect on mortality (beyond difficulties with contraceptive safety and side-effects), contraceptive acceptance and use-effectiveness must be sufficient to affect the pace and pattern of child-bearing. There is every evidence to suggest that the Matlab programme in 1977-1981 achieved such an impact. This programme included some education of mothers in nutrition; child-care services were provided through the four sub-centres in the MCH-FP area. In October 1977, when the intensive village-based programme began, prevalence of contraceptive use in the intensive area was 6.9 per cent. Within three months of intensive programme effort, it had climbed to 20.7 per cent; after one year, prevalence of use was 31.8 per cent, and it reached 33.5 per cent by 18 months. It has subsequently remained at about 34 per cent (Bhatia and others, 1980; Rahman and others, 1982). In-depth analysis of the demographic data suggested marked reductions of the crude birth rate and the total and general fertility rates in the intervention population as compared with the comparison population (Phillips and others, 1982).

Effective contraception may affect mortality through several possible mechanisms. As the rate of new entrants into the population declines, fertility reduction would influence the age structure. In high-fertility and high-mortality populations, where the number and rate of new entrants is large and where a substantial proportion of all deaths is concentrated among the very young, such a change of age structure would have a significant impact on the crude death rate. A second effect of effective contraception is an alteration in the pattern and composition of births according to associated risk factors, such as maternal age and parity, birth spacing and the socio-economic profile of births. A third consequence, perhaps less direct and longer-range, would be biological and socio-economic changes induced by family planning that could reduce mortality risk, and processes such as prolonged breast-feeding, improved maternal nutrition and increased availability of limited intra-family resources for fewer members.

Figure VI examines the effect of changing age structure on the crude death rate due to the contraceptive services in the Matlab intervention and comparison areas. The number of deaths is separated into three age groups (infants, children 1-4 years, and adults aged 5 and over) and plotted by three-month periods for the intervention and comparison areas. Among infant deaths, a reduction of numbers is first observed in the third quarter of 1978, coinciding with the initial reduction of pregnancy terminations. This time period was prior to the impact of the tetanus programme. Most of the effect thus can be presumed to be secondary to the reduction of fertility. Except for the first quarter of 1979, the reduced number of infant deaths in the intervention area persisted for the remainder of 1978 and 1979.

In contrast to infant deaths, the number of 1-4 year deaths among children in the intervention area does not exhibit a reduction until the second quarter of 1979. By that time, oral rehydration for diarrhoea and nutrition education had already been instituted. A portion of the difference in late 1979 could be attributed to a reduction of the number of children at risk due to the reduced number of infants born one year earlier in the intervention area, but this effect is too small to account for the observed differences.

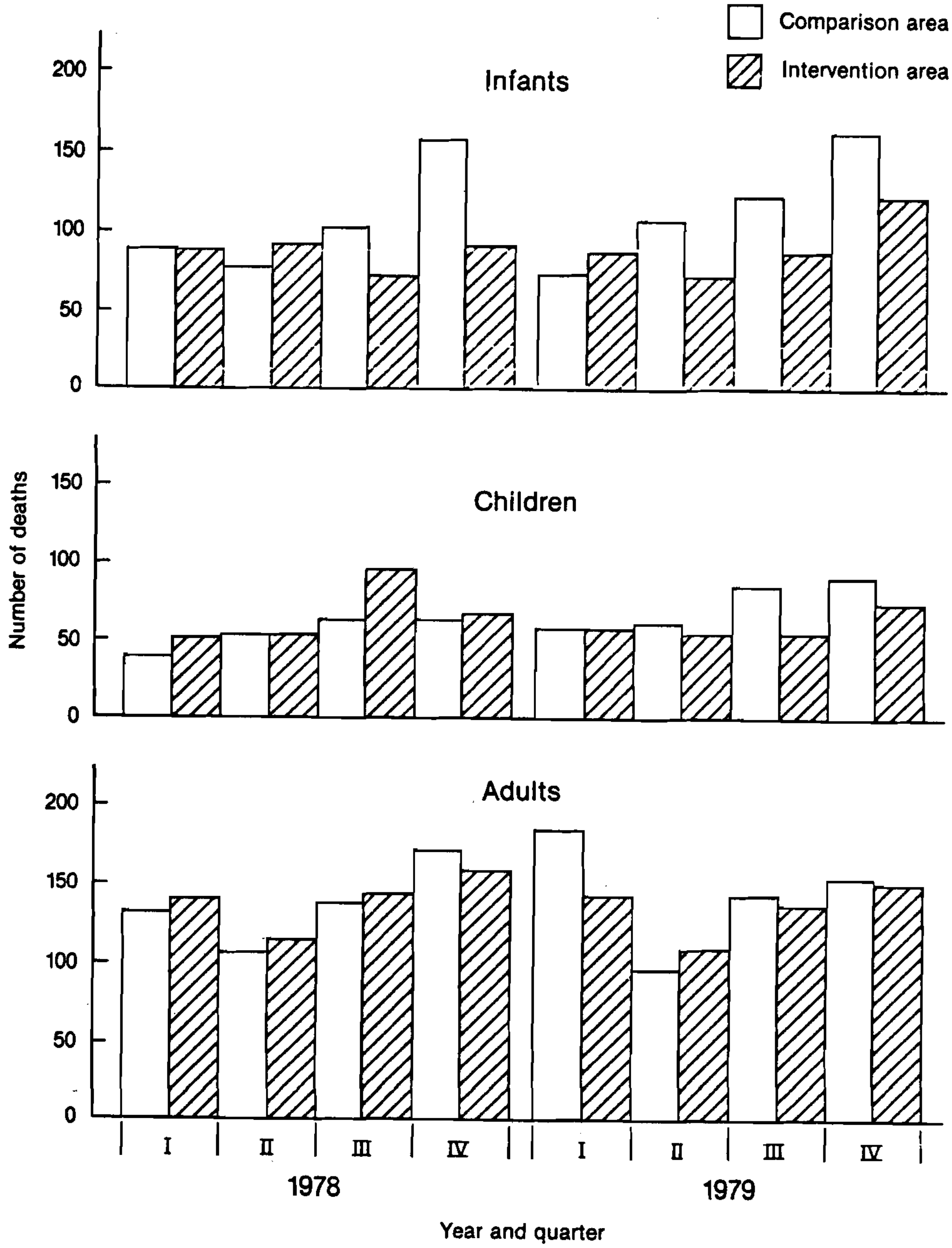
To quantify the effect of changing age structure on the observed mortality differences, one could apply the observed age-specific mortality rates to an age-standardized population to determine how much of the crude death rate changes are due to the reduction of fertility. A crude estimate, however, is possible by examining the age structure of mortality in previous years. In 1976-1977, 35.0 per cent of all deaths occurred to infants in Matlab. A reduction of the crude birth rate by 26.0 per cent in 1979 (table 129), therefore would imply a 9.1 per cent (35.0 per cent × 26.0 per cent) reduction in the overall number of deaths. This reduction of 9.1 per cent explains nearly half of the 22 per cent reduction of the crude death rate observed in the intervention area in 1979 (table 129).

Tetanus immunization

Tetanus neonatorum is one of the leading causes of infant death throughout the world, accounting for up to one third of all neonatal deaths in some developing countries (Bytchenko, 1966; Miller, 1972). One approach to the prevention of this problem is through improving the quality of prenatal, obstetric and postnatal maternal and child health services. Another complementary approach is the active immunization of women before or during pregnancy with tetanus toxoid (from Rahman and others, 1982).

Any programme designed to protect all neonates by means of active immunization of mothers confronts two strategic choices. The first is the immunization of women during pregnancy with two injections of an aluminium-absorbed tetanus toxoid. This immunization procedure is highly efficacious, but its implementation depends upon the capacity to identify in a timely manner all eligible women; to maintain a "cold-chain" for vaccine preservation, transport and delivery; and to ensure continuous provision of health services. In many developing countries such an advanced health infrastructure has not yet been developed, and in these countries mass immunization of women, both pregnant as well as non-pregnant, is an alternative strategy. However, mass immunization campaigns may disrupt rather than strengthen the village-based basic health service infra-

Figure VI. Number of deaths of infants, children aged 1-4 years, adults aged 5 + years in treatment and comparison areas, during 1978 and 1979, by quarter



structure, organization and development. The constraints to this approach also include logistic difficulties in delivering two immunizations to the eligible population and in providing booster immunizations at appropriate intervals (Meira, 1973; Black and others, 1980).

Work in progress at Matlab provides a unique opportunity to study the effectiveness of certain aspects of these two strategies. In 1974, during a field trial of cholera toxoid vaccine, two injections of an aluminium phosphate tetanus-diphtheria toxoid were provided as a control to a randomly assigned group of non-pregnant women.

Beginning in June 1978, a programme of immunizing women during pregnancy with aluminium-absorbed tetanus toxoid was initiated in conjunction with the implementation of a village-based maternal and child health and family planning programme in half of the same Matlab surveillance area. Throughout the period of these two programmes, the International Centre for Diarrhoeal Disease Research, Bangladesh, maintained an independent, longitudinal vital registration system, identifying all births and deaths in the study area. As a consequence, precise data are available on the neonatal mortality experience of children born to mothers who were immunized with tetanus toxoid during pregnancy, before pregnancy, or never immunized.

Table 132 presents the number of live births in this study analysed according to maternal tetanus immuniza-

TABLE 132. NUMBER OF LIVE BIRTHS BETWEEN 1 SEPTEMBER 1978 AND 31 DECEMBER 1979 ACCORDING TO THE IMMUNIZATION STATUS OF THEIR MOTHERS

Immunization status	*MCH-FP area*	*Comparison area*	*Total*[a]	
Fully immunized[b]				
While non-pregnant in 1974 ..	436	520	956	(9.7)
During pregnancy in 1978-1979	934	-	934	(9.5)
Mixed or partially immunized[c]	495	234	729	(7.4)
Non-immunized	2 379	4 858	7 237	(73.4)
Total number of live births	4 244	5 612	9 856	(100.0)

[a] Figures in parentheses represent percentage.
[b] Acceptance of 2 injections either in the 1974 programme or in the 1978-1979 programme.
[c] Partial immunization means acceptance of 1 injection either in 1974 or in 1978-1979. Mixed immunization means acceptance of 1 or 2 injections in 1974 and again 1 or 2 injections in 1978-1979.

tion status. The mothers of 956 infants (9.7 per cent) had accepted full immunization (two injections) while non-pregnant during the July-August 1974 programme, and 934 (9.5 per cent) accepted full immunization during pregnancy in the 1978-1979 programme. The mothers of the remaining infants (729 or 7.4 per cent) accepted partial immunization (one injection in one or the other programme, or partial immunization in one programme and full immunization in the other, or full immunization in both the programmes). None of the study mothers was exposed to any other national or local tetanus immunization programme.

Examination of the neonatal mortality rates (data not shown here) for the study infants, according to the day of death and the immunization status of the mother, suggests that the infants whose mothers had received full immunization while not pregnant in 1974 and the infants whose mothers had received full immunization during pregnancy in 1978-1979 had lower death rates between days 5 and 12 and 6 and 15, respectively, compared with the infants whose mothers had not accepted immunization on either occasion. The three-day moving average is shown in figure VII, and a similar pattern emerges, differences in mortality rate being observed between day 4 and day 16 between the non-immunized group and the group immunized in 1978-1979 and between day 4 and day 13 between the non-immunized group and the group immunized in 1974. The prominent increase in deaths on days 19 to 21 in the 1978-1979 immunized group was due to the death of two pairs of twins.

Table 133 shows the overall rates of neonatal mortality (days 0-28) and the neonatal mortality on days 4-14, when tetanus is considered to be the main cause of death (4). The differences in neonatal mortality rates (both 0-28 and 4-14 days) between the 1978-1979 fully immunized group and the non-immunized group were statistically significant ($P<0.01$). The difference between the 4-14 day neonatal mortality rates for the 1974 fully immunized group and the non-immunized group was statistically significant ($P<0.05$) in the MCH-FP area only. All other comparisons were not significant.

Nutritional status and general consideration

Anthropometric studies to assess nutritional status have been done periodically for some villages in the Matlab area. Figure VIII shows average weight by age data

Figure VII. Number of infant deaths (per 1,000 surviving infants), according to day after birth (3-day moving average) and maternal tetanus immunization status, for infants born between 1 September 1978 and 31 December 1979, in Matlab, Bangladesh

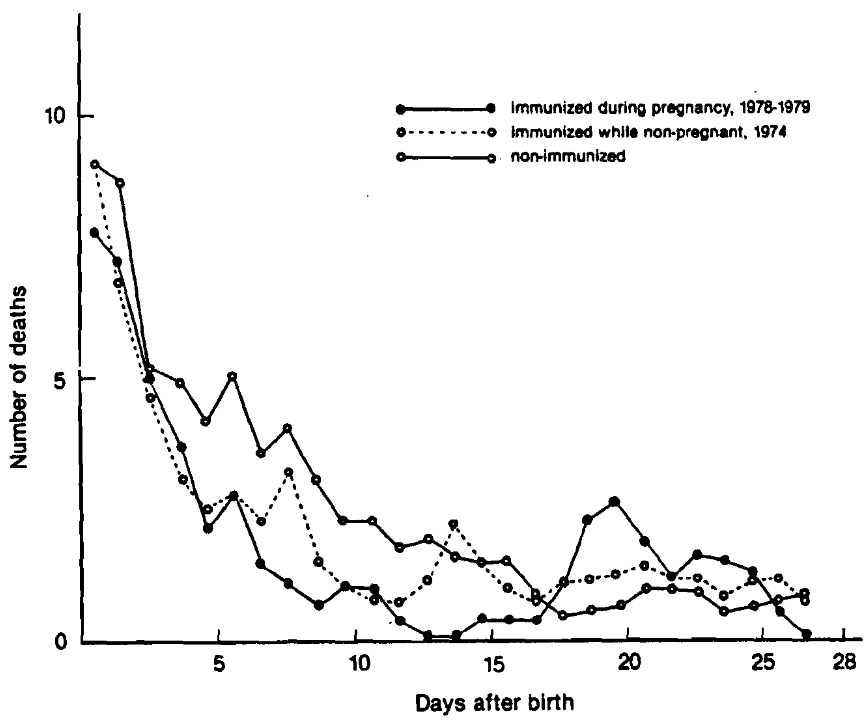
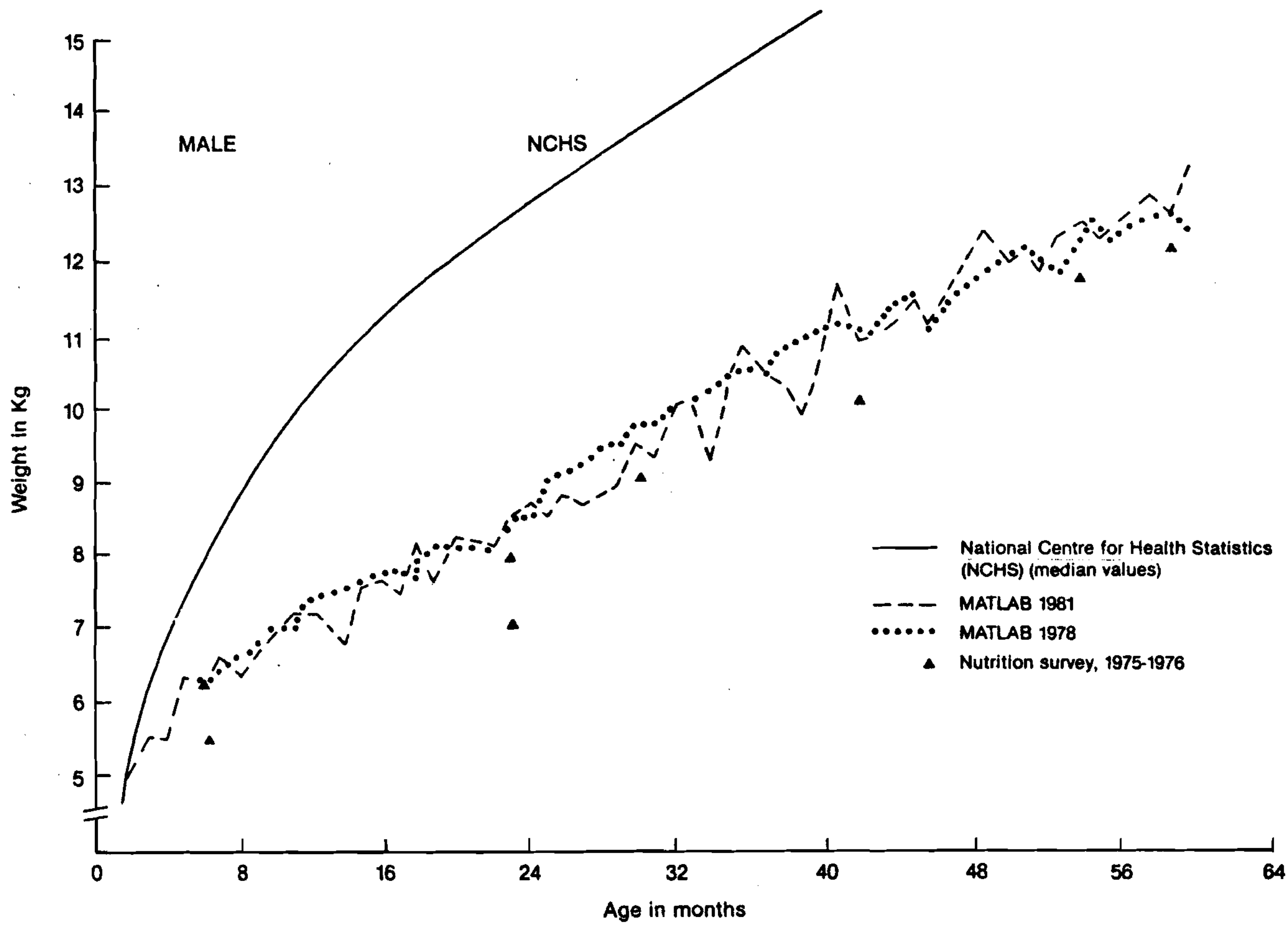


TABLE 133. NEONATAL AND 4-14 DAY MORTALITY AMONG THE LIVE BIRTH COHORT (1 SEPTEMBER 1978-31 DECEMBER 1979), ACCORDING TO MATERNAL IMMUNIZATION STATUS

	MCH-FP area		*Comparison area*		*Total*	
Immunization status	*Number*	*Rate*	*Number*	*Rate*	*Number*	*Rate*
Fully immunized while non-pregnant (1974)						
Live births	436	-	520	-	956	-
Neonatal (0-28 day) deaths	28	64.2	33	63.5	61	63.8
4-14 day deaths	7	16.1[e]	12	23.1	19	19.9
Fully immunized during pregnancy (1978-1979)						
Live births	934	-	-	-	934	-
Neonatal (0-28 day) deaths	40	42.8[c]	-	-	40	42.8[a]
4-14 day deaths	10	10.7[d]	-	-	10	10.7[b]
Non-immunized						
Live births	2 379	-	4 858	-	7 237	-
Neonatal (0-28 day) deaths	199	83.6[c]	368	75.7	567	78.3[a]
4-14 day deaths	82	34.5[d,e]	164	33.8	246	34.0[b]

NOTE: $P < 0.01$ for comparisons of the pairs of figures marked a,b,c,d.
$P < 0.05$ for comparison of the pair of figures marked e.
All the other comparisons were not significant.

Figure VIII. Weight in kilograms by age in months for male children under 60 months



for male children under 5 years of age for the years 1977 and 1981. The female relation appears similar. Superimposed on the grouped data are the corresponding National Centre for Health and Statistics standards (median values) as well as the corresponding mean values of the national nutrition survey of 1975-1976. On the one hand, one notices that children in the Matlab area fall well below the National Centre for Health and Statistics standards after the first six months. On the other hand, Matlab data show that children in the area are possibly better nourished on the average than their national counterparts.

The prevalence of malnutrition was examined in another Matlab study where anthropometric measures of 882 children were obtained. Using the Harvard weight-for-age standard, 14.4 per cent of female children were classified as severely malnourished, but only 5.1 per cent of males. The percentage of moderately malnourished girls (59.6 per cent) exceeded that of boys (54.8 per cent). In the normal and mild categories of nutritional status the proportion of males exceeded that of females (Chen, Chowdhury and Huffman, 1980).

In the section on levels and trends in mortality, it has been shown that in Bangladesh, as a whole, mortality rates (per 1,000) fell from around 40 to about 20 during the period 1950-1965. This achievement on a national level has been attributed to vertical programmes like malaria and smallpox eradication; the overall developmental context has not improved rapidly. The availability of drugs and some preventive measures, including the introduction of tube-wells etc., are also considered as reasons for the reduction in death rates. It is suggested that the establishment of rural health complexes would have a direct impact on future reduction of mortality levels (Economic and Social Commission for Asia and the Pacific, 1981). The Teknaf study referred to earlier, showing rapidly falling clinic attendance after three miles, throws some doubt on this approach unless the complexes can be spaced very near to one another.

Studies on tube-well use have also shown that the mere distribution of tube-wells does not diminish the incidence of diarrhoea, since water is utilized from a variety of sources (Curlin, Aziz and Khan, 1977). There is a need for health education including appropriate sanitation; e.g., a small study on hand-washing has shown that the use of soap can diminish incidence rates of shigella (Khan, 1981). Some approaches which appear simple, such as the use of boiled water for drinking, are in fact outside the reach of large sections of the population. A study in fuel use has shown that the costs of boiling water would account for over 30 per cent of a poor family's income (Gilman and others, n.d.).

The Companiganj data on cause of death show that for the period 1975-1978 malnutrition accounted for 13.1 per cent of deaths (table 127). The availability of food is always a crucial question in Bangladesh, and depends heavily on climatic conditions and favourable monsoons. The unsettled political situation during the past decade has also contributed to the problem of the availability of food. Forty-six per cent of families in rural areas and 95 per cent in urban areas have calorie intake below an acceptable level. Iron and vitamin A deficiency are common (Bangladesh Health Profile, 1977). Per capita protein and calorie consumption was estimated to have declined during the 1960-1976 period. The average total calorie intake was estimated at 2,094 in 1975-1976, as compared with 2,301 in 1962-1964 (nutrition survey 1975-1976). Any strategy to reduce mortality must take into account the importance of the stabilization of food stocks and their availability over crisis periods. The fragile economy of the country has been largely responsible for the overall crude death rate for the past decade in Bangladesh remaining at the fairly high level of just under 20 per 1,000.

E. Some cost considerations

In this section some data related to the cost of the Demographic Surveillance System (DSS) and the diarrhoea treatment centre in Matlab are presented. Effective interventions to improve health in developing countries require informative data on the distribution of death and disease over time, space and social group as well as by type of disease and cause of death. Hence the relative cost of data systems is an important, but often overlooked, aspect of health improvement. The collection of mortality data on the DSS is a costly, intensive affair, which cannot easily be replicated elsewhere. A comparison of the costs involved in the DSS with other projects that monitor vital events in "small areas" can provide important elements for policy decisions regarding vital registration. Design and costs of data collection from the Companiganj health project are briefly compared with the DSS to point out some strengths and weaknesses of the two systems.

A detailed description of the DSS was presented at the beginning of this report. The Companiganj health project started as a joint venture of the Government of Bangladesh and a voluntary agency. It was designed to establish a model of the national integrated and family planning programme of 1973 in a single thana. In this model, it was proposed that various features of the Government's programme would be tested and evaluated and that there would be experimentation with certain modifications, particularly local recruitment of women to work in their own unions (a sub-unit of a thana) and the development of a maternal child care programme. In September 1974, a separate evaluation unit was established, which carried out a 10 per cent enumeration survey and began monthly vital registration to record all births, deaths and migrations in a 10 per cent sample of houses. The objective was to observe changes in vital rates which might occur as a result of project interventions and to provide basic information on demographic and health variables in a defined population (Ashraf, Alam and Khan, 1980).

Table 134 presents a comparison of some of the main items distinguishing the Matlab and Companiganj health projects. One striking element is clearly the difference in cost. The DSS has been budgeted to cost around $300,000 per year, in comparison with $20,000 per year for the Companiganj project. On a per capita survey basis, however, the costs are not very different.

Efforts are being made to reduce the costs of the DSS system. An integral part at the moment is supervision of staff, which is effected by the running of speedboats. The rising costs of gasoline make intense supervision a costly affair.

Twenty per cent of the budget has been allocated to transport costs. Personnel costs are high, accounting for nearly half of the overall budget. Cheaper surveillance systems are clearly necessary. The question remains whether the type of intensive field check-ups, in terms both of vital registration and of in-depth studies, that can be done in Matlab are feasible using cheaper surveillance systems.

TABLE 134. ITEMS OF COMPARISON BETWEEN MATLAB AND COMPANIGANJ HEALTH PROJECTS

Item	Matlab project	Companiganj health project
Population (1974)	160 000	114 000
Cost	$300 000 p.a.	$20 000 p.a.
Type	Longitudinal	Longitudinal
Sample	100 per cent	10 per cent systematic
Lowest-level data-collection personnel	Educated female workers	Uneducated female workers
Purpose	Research oriented with special reference to diarrhoeal diseases	Programme evaluation oriented with reference to integrated and family planning programmes
Studies undertaken	Vital rates/several in-depth studies	Vital rates/causes of death
Time period	1966-present	1975-1980
Scope	Related to national and international programmes	Related to national programmes
International staff	Presence continuing	Present for first few years

The Companiganj project has been conducted on a sample basis. The evaluation unit costs about $20,000 per annum. Some of the advantages of the Matlab project are shared by the Companiganj health project. However, intensive field case-control studies have not been carried out in the Companiganj project, since the orientation of the two projects is quite different. Of interest in the Companiganj project is the fact that an evaluation unit can be attached to a health intervention programme without much additional cost (Chowdhury, Ashraf and Aldis, 1978). If one needed vital rates and changes only, evaluation units of the Companiganj type would be sufficient. Similar inverse relations between mortality and socio-economic status were recorded within Matlab and Companiganj. However, even in Companiganj, due to the size of the effects of the famine, it has not been possible to separate out the effects of the programme from those due to the famine.

Limitations of the Matlab project would also apply to the Companiganj health project. For instance, if a long-term use of the same sampled areas were envisaged, a contamination effect would set in. To avoid this, some sort of sample rotation would be necessary. In fact, the Companiganj evaluation unit has been closed for lack of funding. The Companiganj project, too, has suffered from inadequate data reporting: the first full-scale reports covering the five-year period were issued in 1980. This aspect of data processing is one which is overlooked in many projects in developing countries. The time lag between data collection and publication of reports is often as long as three to five years. The value of the results is thus diminished (D'Souza, 1981).

Cost-effectiveness studies of health interventions

The Matlab treatment centre was opened in 1963 to treat diarrhoeal diseases in the area—in particular cholera. While services were provided, the focus of work was mainly on research; a fleet of speedboats were used as ambulances for ethical reasons—to prevent any deaths in the study area. As reported in the health intervention and mortality section, one study (Mosley, Bart and Sommer, 1972) showed that the treatment centre was more effective than a cholera vaccine campaign. During a cholera epidemic it was estimated that the treatment centre averted 159 deaths of the 318 cases treated. The assumption utilized was that 50 per cent of the cases would have died. Inoculation against cholera would have averted fewer than 143 of the hospital cases and thus fewer deaths. In 1980 prices—using a World Bank price index—the cost of treatment per patient would have been $14.91 and the cost per death averted $603.48. Mosley's cost estimates for the treatment centre and an immunization programme suggest that the former would have been more cost-effective. A later study (Oberle and others, 1980) showed that the cost per patient in the hospital was about $11 and the cost per death averted was between $38 and $81. Translated into 1980 prices, costs would have been $13.83 per patient treated and $48 to $102 per death averted. The costs of an immunization campaign were not calculated but were indicated to be higher. The 1980 price conversions mentioned earlier are taken from a working paper (Horton and Claquin, 1982) recently prepared to compare the cost-effectiveness of the Matlab treatment centre with its speedboat ambulance service and an alternative decentralized unit in Sotaki village in the Matlab area. When an ambulance boat was withdrawn from Sotaki the unit was set up with community participation for diarrhoea treatment. The International Centre for Diarrhoeal Disease Research, Bangladesh, supplied the necessary medical and office supplies and trained six volunteers to give oral and IV fluids and certain drugs.

Table 135 presents a summary of cost-effectiveness figures for the Matlab treatment centre, with ambulance costs shown separately, and for the Sotaki clinic. The term "long-run average cost" includes both user-dependent costs (drugs, food, gasoline) and user-independent costs (wages etc.), as well as equipment and depreciation costs. In the determination of costs the concept of economic resource costs was utilized. Even for a

TABLE 135. SUMMARY OF COST-EFFECTIVENESS FIGURES, MATLAB TREATMENT CENTRE AND SOTAKI CLINIC
(*US dollars*)

	Matlab	Ambulance	Sotaki
Long-run average cost per patient	16.77	12.89	3.36
Long-run average cost per severe patient[a]	676.21	178.53	93.59
Long-run average cost per death averted[b]	1 352.40	357.06	187.19
User numbers	10 618	4 359	891
Number of severely dehydrated	263	157	32

Source: S. Horton and P. Claquin, "Cost effectiveness study of hospital and of ambulance services at Matlab treatment centre", International Centre for Diarrhoeal Disease Research, Bangladesh, Working Paper No. 26, May 1982.

[a] Patients for whom severe dehydration was recorded on admission.

[b] It is assumed that 50 per cent of severely dehydrated patients would have died in the absence of treatment.

resource which is available free to the centre, such as the building of the Matlab treatment centre, a cost was imputed equivalent to the cost that would have been necessary to rent the facility. Further, since the treatment centre has a research function, some joint costs had to be allocated partially as a service cost. Various estimates have been provided in the working paper. The maximum variant has been shown in table 135.

The "cost per death averted" by the treatment centre shown in the table is more than twice that estimated by Mosley, and more than twelve times that of Oberle. Clearly there are differences of methodology and assumptions. The Oberle study, for instance, takes no account of expatriate supervision. The estimates of "cost per patient treated" are closer in the various studies if the rising costs of gasoline are reviewed separately. If one compares the table data for the Matlab treatment centre and Sotaki, a first assessment would be that decentralization is cost-effective, even when the high ambulance costs are separated out. However, there are serious problems of comparability—for example, the classification of dehydration status by the volunteers of Sotaki and the staff at the Matlab treatment centre could be different. The economic resource cost of Sotaki could have been underestimated. The efficacy of Sotaki depends to a large extent on the continuing logistic and technical support of the Matlab treatment centre. Estimation of the cost of such support only in terms of supplies delivered would be inadequate. A fairer comparison would estimate the costs of maintaining the whole study area by a set of decentralized units independent of the Matlab treatment centre completely. The ability to handle epidemic situations that occur seasonally should also be compared. The working paper provides interesting results and highlights the complexity of cost-effectiveness studies, particularly when the confounding needs of both research and services are present and must be separated.

This brief section on cost considerations points to the need for further research and standardization of methodology. Questions related to effectiveness, cost and availability have to be studied. Clearly immunization such as that against tetanus is both effective and cost-effective. Measles vaccine is still costly, though quite effective. Both these immunization approaches require a cold chain, which is difficult to maintain in rural areas without electricity. A vaccine for cholera that is effective has still to be developed. Savings in costs for diarrhoea treatment by the use of oral rehydration rather than IV fluid are considerable (Mosley, Bart and Sommer, 1972). Decentralization of treatment to the village or home could also be a future avenue for cost savings as well as ensuring availability. Studies of costs for introducing preventive measures—water, sanitation and health education, especially of the mother—should be undertaken.

F. Conclusion

The brief discussion of the Demographic Surveillance System (DSS) and the various studies done in the Matlab area referred to in this report are an attempt to illustrate the utility of maintaining a "small study area" within which mortality and morbidity processes can be investigated. For a developing country, such an area can provide immensely valuable data about a wide range of health and population issues.

The DSS constitutes one of the most valuable institutional resources of the International Centre for Diarrhoeal Disease Research, Bangladesh, vital for the conduct of certain types of field research in diarrhoeal diseases, nutrition, population and health care.

Seven broad areas in which the system possesses distinct comparative advantages have been identified. These are:

(*a*) The Matlab surveillance system is necessary for health, nutrition and demographic research, which require an accurate account of the population. Such demographic information is essential for the computation of rates. Vital and other rates are essential for field research, particularly for the assessment of the impact of various programmatic or technological interventions (e.g. vaccine, oral therapy, contraceptives);

(*b*) The Matlab surveillance system provides accurate sampling frames for sample surveys or in-depth studies;

(*c*) Because the DSS has been operational since 1966, the age of most children under 18 is known with accuracy in most of the area. Precise age data strengthen selected research in nutrition, population and infectious diseases;

(*d*) Because of the continuous relationship of the Centre for Diarrhoeal Disease Research with the Matlab population, including the provision of health and diarrhoeal disease prevention services, some studies requiring client co-operation may be more easily conducted in this as compared with other areas;

(*e*) The longitudinal nature of the surveillance system facilitates prospective research designs, including the documentation of time trends;

(*f*) The demographic data may reflect national trends, if not national levels, and thus may be helpful for national planning purposes;

(*g*) The DSS may be employed as a field training area in epidemiological, population, nutrition and health care research.

Five limitations of the system are:

(*a*) The DSS is an expensive research instrument operated by an institution which enjoys a high level of autonomy. It does not necessarily represent a replicable model for others who may require surveillance systems for other purposes;

(*b*) The DSS provides reliable measurements of outcome variables (such as births and deaths) but contains little information on antecedent biosocial causes or processes responsible for the observed outcomes. Except where study designs take this into account, only inferences may be made about the determinants of the observed outcomes;

(*c*) The data collection of the surveillance systems is hierarchical and depends upon close supervision. There is insufficient community participation in the data collection or in the use of the information generated;

(*d*) Past intervention research, current health services and multiple, concurrent research designs are only several of the factors that may "contaminate" the study design of any individual study in the research area, sometimes introducting an unquantifiable bias into research results;

(*e*) The transfer of health technology to other areas of Bangladesh, developed in Matlab, may not be easy. Differentials in pay structure, motivation and supervision as well as local political and other problems could be important obstacles to such a transfer.

At the inception of the Matlab project, health intervention was limited to the needs of research projects focusing primarily on vaccine trials; now the limited health interventions in the MCH-FP area constitute a serious attempt to combine service and research goals. Recent studies in Matlab have shown that the MCH-FP project had a sustained effect on lowering fertility rates (Phillips and others, 1982; Stinson and others, 1982). The effect on the mortality level has yet to be thoroughly assessed, though it is likely the apparent reduction in mortality cannot be attributed to a single component such as lower fertility or immunization. Nutrition studies have been made but major nutritional interventions, apart from education, have not been carried out. A study on food allocation (Chen, Huq and D'Souza, 1981) has shown that females may receive less food than males at corresponding ages and requirement levels. This may account for sex differentials in mortality at least partially indicative of cultural bias.

Education, especially of the mother, is an important correlate of mortality levels. During the difficult years of 1974-1977, children under 3 years of age of mothers with no education suffered mortality rates five times higher than children of mothers with seven years or more of education. Health-care delivery systems have to take into account the social stratification of the community. The national health policy will have to focus on selected health-care items that reach the economically and culturally disadvantaged segments of the population having the highest mortality rates, especially in times of crisis.

The Centre for Diarrhoeal Disease Research is studying the possibility of setting up surveillance systems that are based on repeated cross-sectional surveys. Studies of this kind have been undertaken in various countries. However, indirect estimates of mortality based on such surveys have been unable to provide conclusive results (United States National Academy of Science, 1982). Elements of the Matlab health intervention programmes that can be replicated within a framework of normal government inputs and evaluated through a low-cost mechanism are being investigated. A growing need is being felt for field studies to include information on development as well as on health services to evaluate the relative cost-effectiveness of different strategies for reducing mortality. At the Centre, studies are being undertaken relevant to this issue. Problems relating to procedures used by traditional birth attendants and consequent high neonatal mortality have been studied (Bhatia, Chakraborty and Faruque, 1979; Islam and others, 1982 a, b). Training of such personnel and traditional medical practitioners could be a cost-effective approach to reducing mortality. The advantages of decentralization of oral rehydration therapy to small clinics and the family has been referred to in the report.

The reduction described in neonatal mortality rates due to tetanus immunization of pregnant mothers indicates that particular preventive measures are in fact more efficacious, in the short term, in lowering infant mortality rates than alternative policies oriented towards more general development. The relationship between nutrition, morbidity and mortality is now under study; the morbidity indicators which would enable health planners to determine particular sectors of the population at high risk of mortality may be isolated. Intervention programmes could then be better focused if a set of simple input points could be identified. However, long-term and sustained falls in mortality levels would require overall development and availability of food over crisis periods.

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VI. EFFECT OF HEALTH AND NUTRITION INTERVENTIONS ON INFANT AND CHILD MORTALITY IN RURAL GUATEMALA*

*H. L. Delgado,** V. Valverde** and E. Hurtado***

A. The Central American health context

The rural areas of most Latin American countries exhibit high mortality and morbidity. Health professionals are scarce, and available paraprofessional personnel are inadequately trained and underutilized. Furthermore, funds designated for health purposes are severely limited.

In the past, most Governments and private agencies have provided health-related services, such as nutrition supplementation, health care and family planning, through separate, vertical programmes. Recently, Governments and international agencies have slowly moved towards the integration of nutrition and family planning programmes with other health-related services and community development efforts.

On the other hand, the provision of effective health services for rural areas is not easy and there is considerable debate over the most adequate administration of integrated programmes. Although most ministries of public health have decided to extend the health services to rural areas, information concerning the most efficient method of implementing such programmes is at present lacking.

The purposes of the present chapter are: (*a*) to review the current state of knowledge concerning health, nutrition, population and community development in the Central American region, in general, and in Guatemala, in particular; (*b*) to describe the approach and methodology of some simplified health care programmes implemented in different rural areas in Guatemala and discuss their results; and (*c*) to propose a simplified integrated model of health, nutrition and family planning services for rural areas, some of whose components have been extensively tested by the Institute of Nutrition of Central America and Panama (INCAP) during the last 10 years.

B. Health, nutrition and population dynamics in Central American countries

Factors characteristic of underdevelopment are manifest in Central America. These include low average annual per capita income, large proportions of populations residing in rural areas, unequal distribution of land ownership and sizes of plots, semi-subsistence agricultural practices, high levels of illiteracy, limited public sanitation, water supply deficient in quantity, quality and availability, poor personal hygienic practices and, in some cases, language and cultural barriers within the population. Variations exist within the sub-region, however. Panama and Costa Rica have experienced substantial improvement in socio-economic indicators in the last 20 years; the other countries show only moderate evidence of socio-economic progress. The success of Costa Rica and Panama could be attributed to the model of development they adopted. Since the beginning of the last century, the Governments of both countries have emphasized educational programmes to reduce illiteracy rates. In the first half of the present century, social reforms took place, which included the creation of a social security system, the development of housing and the initiation of an income tax and other forms of income redistribution. Moreover, since the late 1960s Costa Rica has been implementing nation-wide programmes designed to deliver services to the people. Among these, the rural health care programmes and the collective food supplementation programmes appear as the main forces responsible for the decline in morbidity, malnutrition and mortality rates. In turn, Panama has been promoting the implementation of rural development projects in those communities exhibiting higher malnutrition, mortality and poverty rates.

As shown in table 136, the rate of population growth for the six countries of Central America varied from 2.3 to 3.5 per cent during the 1975-1980 period. Table 136 also presents estimates of life expectancy at birth in 1950, 1960 and 1970 for the six countries. The difference between the lowest and the highest mortality conditions is 16 years of life expectancy in 1950 (between Costa Rica and Honduras) and 18 years in 1970 (again between Costa Rica and Honduras). In all countries life expectancy increased between 10 and 12 years during the 20-year period, with the exception of Panama, which registered a gain of nearly 15 years. Three of the countries—Costa Rica, Guatemala and Honduras—experienced a more rapid drop in mortality during the 1960-1970 period than during the previous decade. In the other countries the pace of mortality decline slowed down. However, these countries exhibited extremely high rates of mortality decline during the earlier decade; rates that would have been very difficult to sustain (United Nations, 1981).

Table 137 shows estimates of the probability of dying during the first two years of life (denoted $q(2)$) around

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** Institute of Nutrition of Central America and Panama (INCAP), Guatemala, Guatemala.

TABLE 136. DEMOGRAPHIC INDICATORS IN CENTRAL AMERICAN COUNTRIES AND PANAMA

Country	Population estimates (in thousands) (1980)[a]	Surface area (thousands of square kilometres)	Population density	Life expectancy at birth[b] (years) 1950	1960	1970	Fertility rates per 1,000 women[c] (1979)	Crude death rates per 1,000[a] (1975-1980)	Crude birth rates per 1,000[a] (1975-1980)	Growth rate[a] in percentage (1975-1980)
Costa Rica	2 279	51	45	55.9	60.8	67.3	126	4.6	30.7	3.0
El Salvador	4 797	21	228	47.2	56.0	57.4	179	9.4	42.1	2.9
Guatemala	7 262	109	67	40.3	46.0	52.2	187	10.9	41.1	3.0
Honduras	3 691	112	33	40.0	42.2	49.7	207	11.8	47.1	3.5
Nicaragua	2 771	130	21	40.1	48.4	52.3	192	11.8	45.6	2.8
Panama	1 956	76	26	50.2	62.0	64.9	132	6.0	31.0	2.3

[a] *World Population Prospects: Estimates and Projections as Assessed in 1982* (United Nations publication, Sales No. E.83.XIII.5).
[b] Calculated from data given in *Levels and Trends of Mortality since 1950* (United Nations publication, Sales No. E.81.XIII.3).
[c] Pan American Health Organization/World Health Organization, *Health Conditions in the Americas 1977-1980*, Washington, D.C., 1982.

TABLE 137. PROBABILITY OF DYING DURING THE FIRST TWO YEARS OF LIFE (1,000$q(2)$) IN THE CENTRAL AMERICAN COUNTRIES AND PANAMA

Country	Year	Total	Rural areas	Urban areas	Excess of rural rate
Costa Rica	1973	81	92	60	32
El Salvador	1971	145	148	139	9
Guatemala	1973	149	161	120	41
Honduras	1970	140	150	113	37
Nicaragua	1971	149	152	143	9
Panama	1970	58	-	-	-

Source: Levels and Trends of Mortality since 1950 (United Nations publication, Sales No. E.81.XIII.3).

the years 1970-1973. The data suggest that the Central American countries can be divided into two groups: a low two-year mortality group, including Costa Rica and Panama, and a high two-year mortality group, constituted by El Salvador, Guatemala, Honduras and Nicaragua. In all countries, the mortality rates of children under two years of age are consistently higher in rural areas than in urban areas.

As shown in table 138, in most of these countries, the leading reported causes of death are from preventable diseases such as gastrointestinal and respiratory illness, especially influenza and pneumonia. Risk of death from these causes is particularly high in children under 5 years of age. The exceptions to the above are Costa Rica and Panama, where perinatal complications and accidents have become more important causes of death (World Bank, 1980).

A major reason that common infections so often lead to death in these countries is their interaction with malnutrition (Scrimshaw, Taylor and Gordon, 1968). Information on growth retardation ascertained by anthropometric indicators is available for children below 5 years of age from national surveys conducted in the past five years in Costa Rica, El Salvador, Guatemala and Panama (see table 139). For the interpretation of Table 139, a child with weight retardation is defined as one having a weight-for-age relationship below 75 per cent of the value of the 50th percentile of weights of children of the same age and sex from a standard (World Health Organization, 1979). The percentage of children exhibiting marked weight retardation dropped in all countries with data from 1965-1966 to the late 1970s. Large reductions were observed in Costa Rica and El Salvador, but there was little change in Guatemala and Panama, although Panama had already achieved a low level of growth retardation by the time of the 1967 survey. Based on the information available, it is possible to estimate that approximately 60 per cent of the children under the age of 5 years living in the Central American isthmus suffer from some form of malnutrition (defined as weight for age $<$ 90 per cent).

The national nutrition surveys conducted in all six countries in 1965-1966 and more recently in some of these countries indicate that the average diet, particularly in rural areas, is deficient in calories and proteins (Valverde, Arroyave and others, 1981). Other nutritional problems identified in all countries in the 1965-1967 nutritional survey include hypovitaminosis A, iron and folate-related anaemias and iodine deficiency. Table 139 also presents the calorie and protein supply per capita for the countries of the isthmus, based on food balance sheets. Costa Rica, Nicaragua and Panama exhibit higher levels of energy and protein supply than El Salvador, Guatemala and Honduras.

TABLE 138. DEATH RATES PER 100,000 FOR SPECIFIC CAUSES IN CHILDREN UNDER 1 AND AGED 1-4 YEARS IN CENTRAL AMERICAN COUNTRIES AND PANAMA AROUND 1980

Country	Year	Age-specific death rates: Under 1 year	Age-specific death rates: 1-4 years	Diarrhoeal diseases: Under 1 year	Diarrhoeal diseases: 1-4 years	Influenza and pneumonia: Under 1 year	Influenza and pneumonia: 1-4 years
Costa Rica	1979	2 212.3	129.2	196.4	11.3	225.3	11.7
El Salvador	1974	5 341.1	608.2	1 276.1	182.1	370.3	32.7
Guatemala	1978	7 226.6	1 309.9	1 345.4	408.6	1 229.5	220.5
Honduras	1978	2 689.6	478.6	519.5	92.8	179.8	34.8
Nicaragua	1977	3 516.3	360.0	1 229.0	-	251.1	-
Panama	1974	3 158.9	465.7	293.7	78.8	403.6	64.1

Source: Pan American Health Organization/World Health Organization, *Health Conditions in the Americas 1977-1980*, Washington, D.C., 1982.

TABLE 139. NUTRITIONAL STATUS OF CHILDREN UNDER 5 YEARS OF AGE, AND DAILY CALORIE AND PROTEIN SUPPLY PER CAPITA IN CENTRAL AMERICAN COUNTRIES AND PANAMA, 1966-1980

	Nutritional status[a]				Daily calorie and protein supply per capita[b]		
					1975-1977 average		As percentage of calorie requirements (1977)
Countries	*Year*	*Proportion of population less than 75% of standard weight-for-age*[c]	*Year*	*Proportion of population less than 75% of standard weight-for-age*[d]	*Calories*	*Protein (grams)*	
Costa Rica	1966	13.7	1978	7.0	2 487	58.1	116
El Salvador	1965	26.0	1978	10.4	2 071	54.4	90
Guatemala	1965	32.4	1979/80	29.5	2 023	53.7	98
Honduras	1966	29.5	-	-	2 084	51.5	89
Nicaragua	1966	15.0	-	-	2 452	70.4	109
Panama	1967	11.9	1980	11.6	2 346	57.8	101

[a] National nutritional surveys.
[b] Food and Agriculture Organization of the United Nations, Food Balance Sheets, 1980.
[c] Standard: IOWA.
[d] Standard: WHO/NCHS.

In most Central American countries, medical resources are concentrated in urban areas. The shortage of professional health personnel in rural areas is documented in table 140. Those paraprofessional personnel available (auxiliary nurses, health promoters and midwives) are generally poorly trained and unable to manage adequately some of the most prevalent and basic problems requiring medical attention. The current uneven distribution of professional health personnel and their sporadic visits to rural areas is further complicated by an inadequate communication-transportation infrastructure. Rural areas have considerably less health facilities at their disposal, lack of safe water and inadequate sanitation (Delgado, 1983). Hence it is not surprising that the half or more of the population living in rural areas experience higher risks of mortality and morbidity than their urban counterparts.

As shown in table 140, as of 1977 the Central American countries, particularly Guatemala and Nicaragua, allocated a very small percentage of their total national budgets to health (World Bank, 1980). Moreover, the largest part of the budgets of all health services, both public and private, is consumed by maintenance and administrative costs, or by institutionalized medical attention and custodial services. Even these services, which are only palliative, tend to be concentrated in urban areas. Thus, only a small portion of what is generally a very limited national health budget to begin with is spent on environmental sanitation, infectious disease control and maternal and child care in rural areas. Nutrition programmes are usually restricted to food supplements distributed in maternal and child health care programmes and/or through vertical programmes. Family planning services are administered by clinics and health posts. In most cases, food supplements and contraceptive methods do not reach the population at risk.

C. THE GUATEMALAN SITUATION

Guatemala has the largest population of the countries in the Central American isthmus. Its population of 7.3 million in 1980 was more than twice that of Nicaragua. The annual population growth was estimated at 3 per cent for the 1975-1980 period, resulting from a crude death rate of 11 per 1,000 and a crude birth rate of 41 per 1,000. A unique characteristic of Guatemala, in comparison with the other Central American nations, is the large proportion of indigenous population. Based on the 1973 census, 44 per cent of the population was indigenous, mostly living in rural areas (Diaz, 1977).

Official statistics do not completely disclose the true magnitude of the health and nutritional problems existing in Guatemala. Nevertheless, the role of nutritional deficiencies and infectious diseases as underlying causes of death, particularly in the most vulnerable age groups of children under 5 years and women during their reproductive years, has been highlighted. Child mortality in Guatemala constituted more than 50 per cent of all registered deaths in 1971, whereas maternal mortality was between 1.5 and 2.0 deaths per 1,000 births during the 1964-1973 period (Guatemala, 1979).

The age-specific death rates, total and for the two major causes of death, are presented in figures IX and X (Arriaga, 1981). Several aspects should be pointed out. First, children are at greatest risk of death in the first 5 years of life, and mortality declines rapidly from very high rates in those years to the lowest rates in the 5-14-year age group. Second, the leading causes of death in each group are always infectious and parasitic diseases, respiratory diseases, deaths of unknown causes and other causes of death. Avitaminosis and anaemias caused about 4 per cent of all deaths in children 0-4 years of age in 1978.

Figures IX and X also show that Guatemala experienced a decline in mortality between 1961 and 1971. The mortality rate in children 0-4 years of age was 40 per 1,000 in 1961 and 38 per 1,000 in 1971, representing a 5 per cent decrease. However, as shown more clearly in figure XI, the mortality decline occurred only for boys, not for girls, and was mostly from a decline in deaths from infectious and parasitic diseases. In 1968 about 25 per cent of all deaths in children 0-4 years of age were caused by enteritis and other diarrhoeal diseases; these two diseases made up 60 per cent of all deaths attributed to the infectious and parasitic cause-group. These results mirrored data for 1971, at which time 56 per cent of all deaths in children below 5 years of age were caused by infectious and parasitic diseases, of which 48 per cent were attributed to diarrhoeal disease, 26 per cent to measles, 16 per cent to whooping cough and 10 per cent to parasitic infestations.

TABLE 140. HEALTH RESOURCES AND EXPENDITURES IN PUBLIC SERVICES IN CENTRAL AMERICAN COUNTRIES AND PANAMA

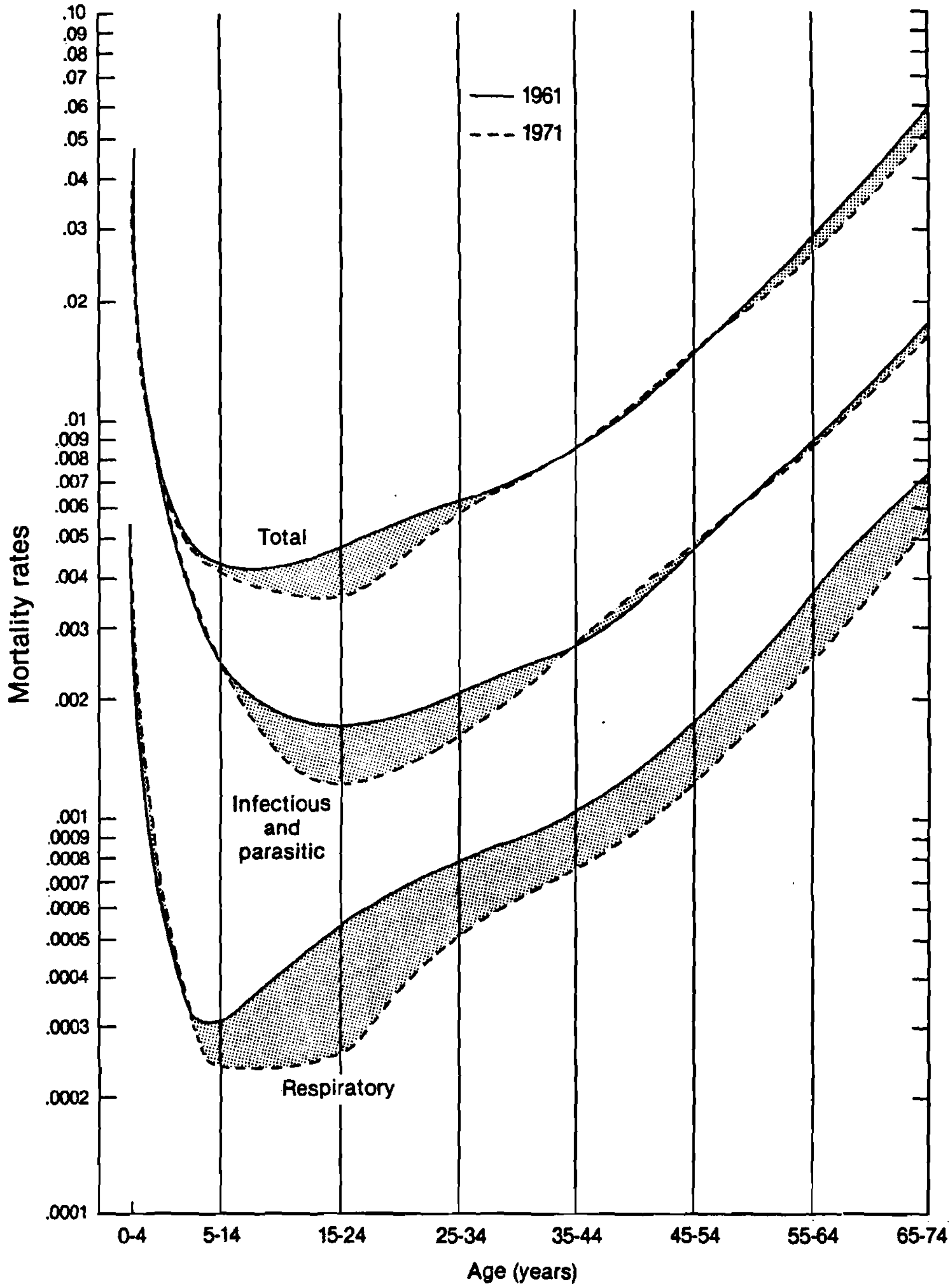
	Human health resources per 10,000 inhabitants[a]						*Physicians per 1,000 inhabitants*[b]			*Number of minimal health posts and percentage increment in 1971-1980*[a]		*Expenditure in public services as percentage of total gross domestic product*[c]	
	Physicians		*Nurses*		*Auxiliary Nurses*								
Country	*1971*	*1978*	*1971*	*1978*	*1971*	*1978*	*Year*	*Capital and major cities*	*Rest of country*	*1971*	*Percentage increment*	*1960*	*1977*
Costa Rica	5	7	4	6	13	16	1968	12	3	49	328	10	16
El Salvador	3	4	3	3	5	6	1972	14	1	95	81	10	11
Guatemala	3	5	2	2	2	6	1971	15	0	150	317	8	6
Honduras	3	3	2	1	6	8	1971	12	2	148	249	11	14
Nicaragua	..	..	..	..	..	..	1972	17	5	..	..	9	8
Panama	7	8	6	7	13	16	1972	19	3	190	70	..	..

[a] Pan American Health Organization/World Health Organization, *Health Conditions in the Americas, 1977-1980,* Washington, D.C., 1982.

[b] J. W. Wilkie and P. Reich (eds.), *Statistical Abstracts of Latin America,* Los Angeles, University of California at Los Angeles, 1977.

[c] World Bank, World Development Report, 1980.

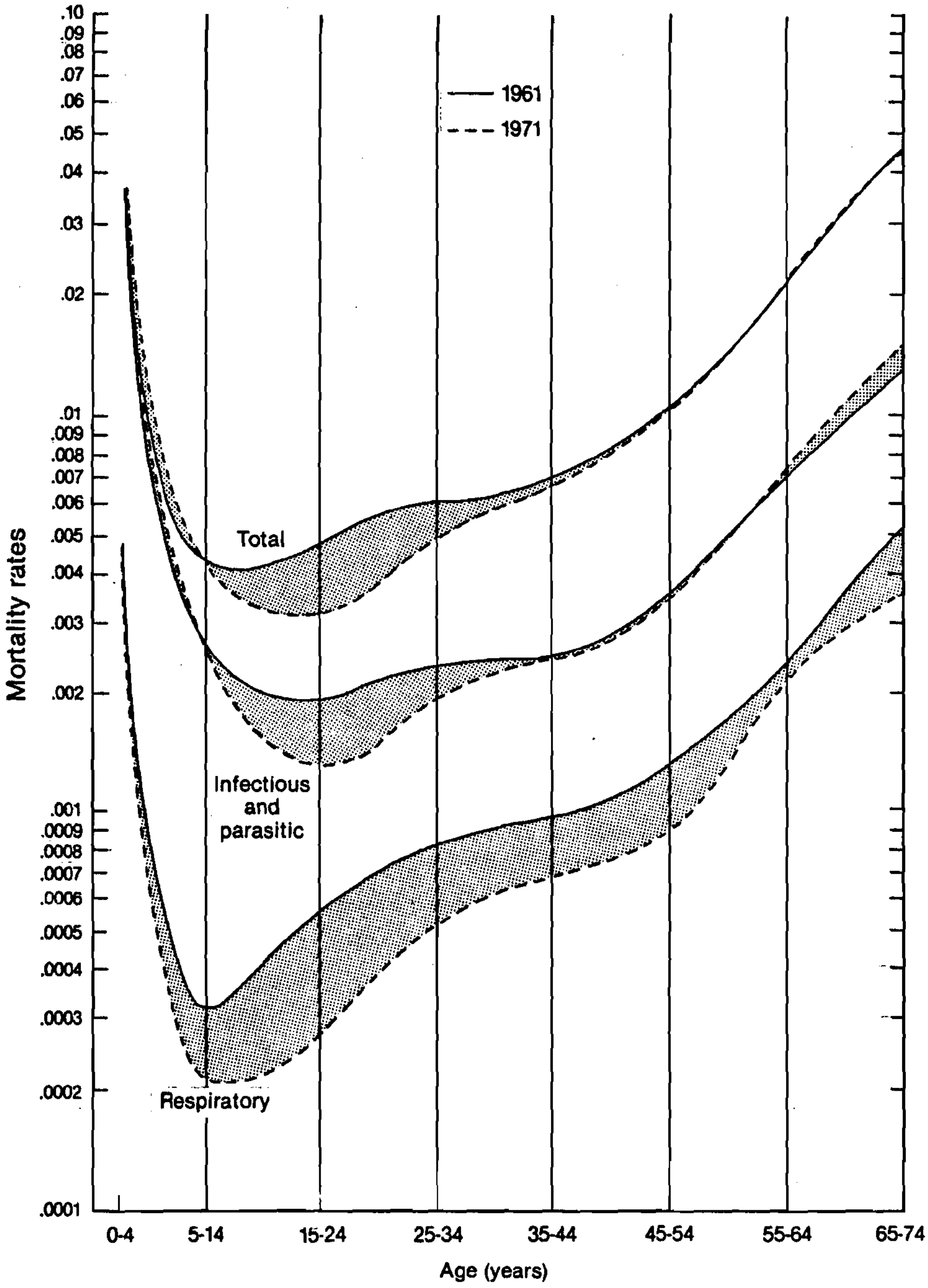
Figure IX. Age-specific mortality rates in 1961 and 1971 for Guatemala males (total and major causes of death)



A decline in mortality is also observed during infancy; infant mortality rates declined by 12 per cent between 1959-1961 and 1972-1973.

The information presented above is based on official statistics and suffers from incompleteness. The Centro Latinoamericano de Demografía (CELADE) has estimated underregistration to be about 20 per cent in registered deaths during infancy and about 5 per cent in the groups from 1 to 5 years of age (Behm and Vargas, 1978). In addition, the comparisons of mortality rate from different periods have limitations due to differentials in underreporting and the consequent bias. In the absence of reliable registration data, techniques using census data on children ever born and children surviving by age of mother provide an easy way to calculate the probability of dying before reaching certain ages (Trussell and Preston, 1980). Based on samples of the censuses of 1964 and 1973, Haines, Avery and Strong (1981) estimated, through an indirect technique called the Surviving Children Method (also called the Preston-Palloni Method), the probability of children dying before reaching 2 years of age ($q(2)$). It should be noted that the results from the 1964 census roughly apply to 1961 and the results from the 1973 census apply approximately to 1970. From here on these reference dates will be referred to. Data for the 22 departments of Guate-

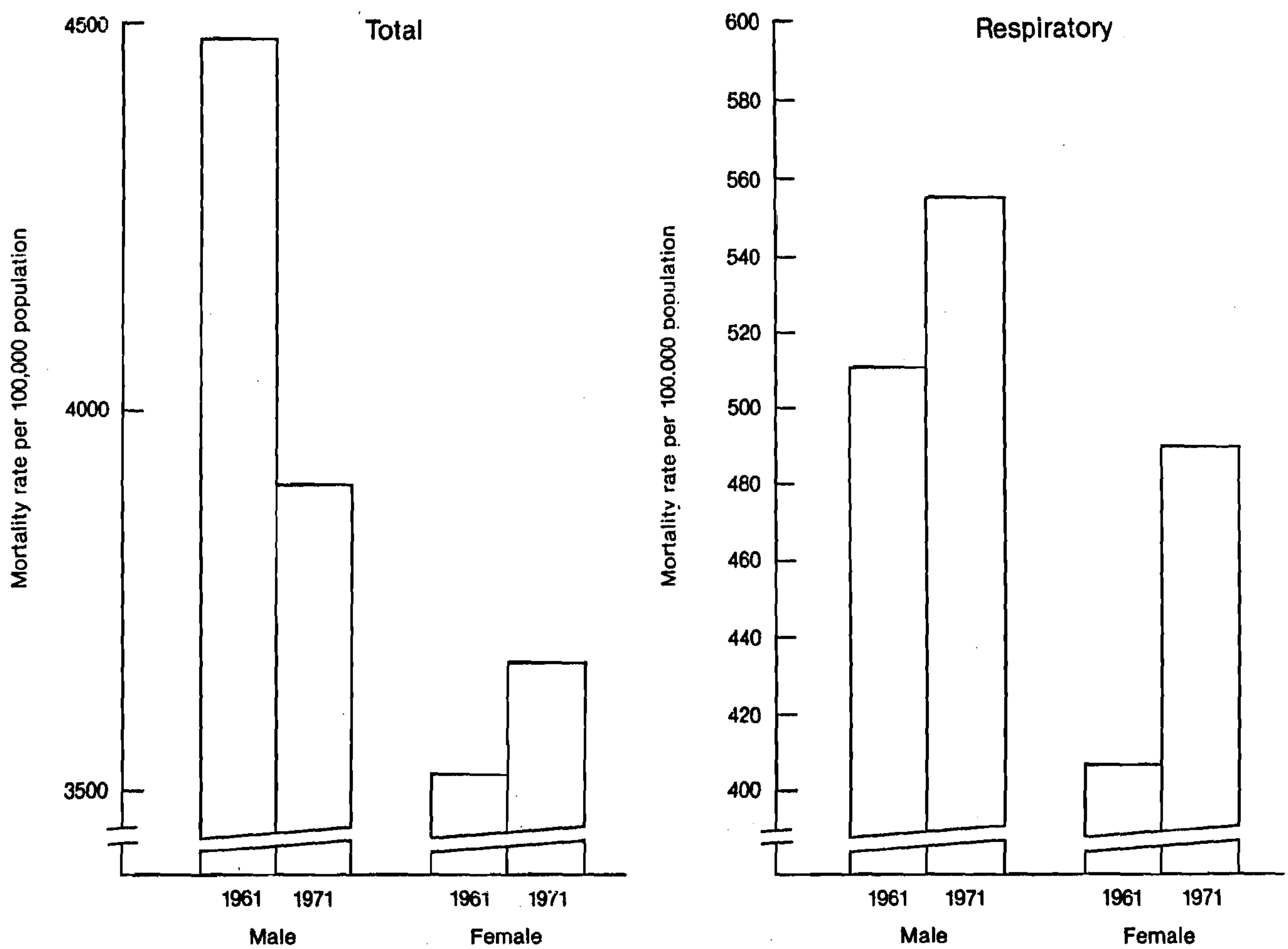
Figure X. Age-specific mortality rates in 1961 and 1971 for Guatemala females (total and major causes of death)

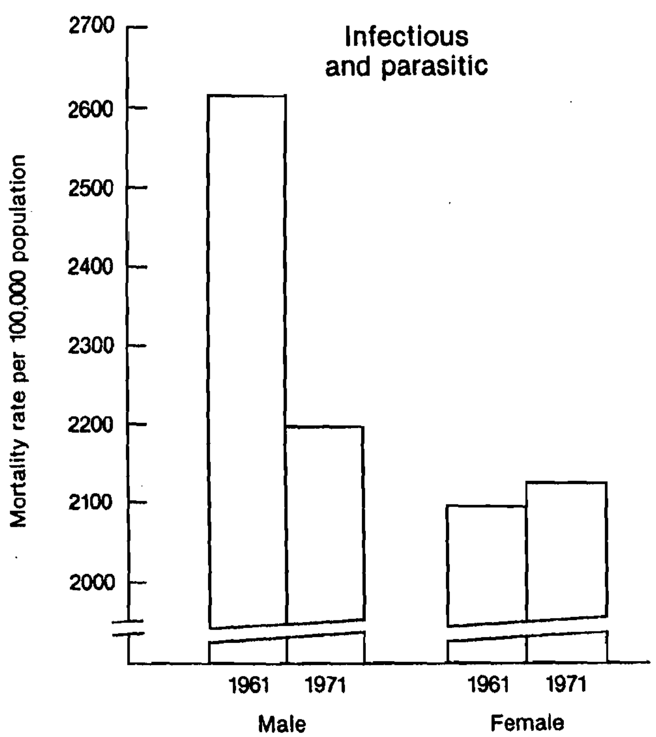


mala, for both rural and urban areas, are presented in table 141. The changes in $q(2)$ between 1961 and 1970 by ethnicity, region and urban and rural residence are given in table 142. These data reveal that early-age mortality is considerably higher in the indigenous population than in the non-indigenous, in both rural and urban areas. Lower mortality rates are found in urban areas.

The analyses of changes in mortality rates between 1961 and 1970 showed a reduction in mortality, especially in urban areas and in non-indigenous populations. Further analyses indicated that the level of education of the mother was directly associated with the magnitude of the estimated mortality decline. Urban-rural residence and level of education appear to be two of the most important variables accounting for mortality differentials, since they are highly intertwined with the processes of modernization, industrialization, expansion of services etc. Based on this information it could be postulated that the reduction in mortality rates is due principally to the impact of medical technology. Indeed, the utilization of more sophisticated technology and application of increased knowledge about the cure and prevention of disease, without parallel improvements in the standard of living of the population, could have produced a significant decline in mortality. However, as described above, in rural Guatemala infectious and parasitic diseases and

Figure XI. Mortality rates in children aged 0-4 years between 1961 and 1971, by sex and causes of death, Guatemala





malnutrition are the underlying causes of death. These conditions reflect the poor living conditions of the areas, and the reduction of the risk of death from these factors is amenable to an improvement of living conditions and the implementation of basic preventive measures.

One of the problems facing Guatemala is that of bringing basic health and medical services to rural, often isolated areas of the country. As previously indicated, there exists a high concentration of both physicians and facilities in urban sectors. For the rural ill, this frequently implies a journey to seek medical attention, costly in time, money and effort. At the same time, paraprofessional health personnel, although more numerous than physicians and graduate nurses and more evenly distributed throughout the country, are ill prepared to carry out simple and essential medical diagnosis and therapy which could prove essential to health if applied in a timely fashion (Guatemala, 1970).

Recognizing this situation, the Guatemalan Ministry of Public Health declared one of its major objectives to be the improvement of medical services in rural areas. The five-year health plan includes among its objectives the extension of health services to rural areas, improved utilization of paramedical personnel and community participation in health planning and action.

TABLE 141. PROBABILITY OF DYING DURING THE FIRST TWO YEARS OF LIFE PER 1,000 LIVE BIRTHS, BY DEPARTMENT AND RESIDENCE IN GUATEMALA, 1961 AND 1970, BASED ON NATIONAL SAMPLES OF THE CENSUSES OF 1964 AND 1973

	Total		*Urban*		*Rural*	
Departments	*1961*	*1970*	*1961*	*1970*	*1961*	*1970*
Guatemala	165	92	152	82	219	143
El Progreso	192	151	181	181	194	140
Sacatepéquez	223	150	248	135	157	178
Chimaltenango	239	172	203	153	259	182
Escuintla	178	198	164	183	183	203
Santa Rosa	176	155	198	148	171	157
Sololá	237	218	209	213	255	221
Totonicapán	224	178	219	186	224	182
Quetzaltenango	196	160	170	127	208	180
Suchitepéquez	159	164	119	144	172	171
Retalhuleu	182	147	174	162	186	140
San Marcos	164	176	158	128	165	182
Huehuetenango	193	171	246	160	184	173
Quiché	185	163	223	125	180	167
Baja Verapaz	96	152	121	159	95	152
Alta Verapaz	158	164	266	161	147	164
Petén	145	161	158	123	132	173
Izabal	166	157	122	141	162	159
Zacapa	163	143	111	104	181	156
Chiquimula	165	186	171	116	164	201
Jalapa	156	156	131	118	164	167
Jutiapa	190	157	214	153	199	158
GUATEMALA TOTAL	178	155	171	116	182	172

Source: M. R. Haines, R. C. Avery and M. A. Strong, "Differentials in infant and child mortality and their change over time: Guatemala, 1959-1973", paper presented at the annual meeting of the Population Association of America, Washington, D.C., 26-28 March 1981.

TABLE 142. PROBABILITY OF DYING DURING THE FIRST TWO YEARS OF LIFE PER 1,000 LIVE BIRTHS, BY REGION, ETHNICITY AND RESIDENCE IN GUATEMALA, 1961 AND 1970, BASED ON NATIONAL SAMPLES OF THE CENSUSES OF 1964 AND 1973

	Total		*Urban*		*Rural*	
	1961	*1970*	*1961*	*1970*	*1961*	*1970*
Guatemala	178	155	171	116	182	172
Regions						
Central	165	92	152	82	219	143
South	192	176	183	152	196	184
East	172	159	170	137	172	164
North	170	165	224	148	163	167
Ethnicity						
Indigenous	193	182	211	171	190	185
Non-indigenous	165	129	158	96	173	155

Source: M. R. Haines, R. C. Avery and M. A. Strong, "Differentials in infant and child mortality and their change over time: Guatemala, 1959-1973", paper presented at the annual meeting of the Population Association of America, Washington, D.C., 26-28 March 1981.

Within the five-year plan, priority has been given to the reduction of illness and deaths due to preventable and reducible diseases, especially communicable diseases, perinatal diseases and malnutrition. Emphasis has been placed on the most vulnerable groups of the population: those younger than 5 years and pregnant and lactating women. Plans specifically state that medical attention programmes must be complemented with preventive care and health promotion efforts.

However, the provision of effective integrated health services for rural areas is not easy and information concerning the most efficient methods for implementing such programmes is presently lacking. The next section describes the approach and methodology of a simplified health care programme, implemented in different settings in rural Guatemala, and discusses some of its major results.

D. SIMPLIFIED HEALTH CARE PROGRAMMES IN RURAL GUATEMALA

In 1969 the Division of Human Development of the Institute of Nutrition of Central America and Panama (INCAP) began a study of the effects of nutrition on mental development and physical growth of preschool children (Growth and Development Project). This project was carried out in rural communities and included a supplementary feeding program and a simplified preventive and curative health care programme.

In 1976 two other health intervention projects were implemented by the Division; one in four Indian communities in the Department of Sololá (Sololá Project) and the other in 12 coffee plantations near the town of Patulul, in the Department of Suchitepéquez (Patulul Project). Although these projects have been well described elsewhere (Habicht, 1973; Delgado, Farrell and Klein, 1978), a brief description of their principal characteristics may be appropriate here.

The Growth and Development Project

In January 1969, a longitudinal study of the effects of nutrition on the mental development and physical growth of preschool children was begun. The project was implemented in four rural Ladino (non-Indian) communities of the Department of El Progreso, in the eastern region of Guatemala. Child mortality as measured by $q(2)$ in the rural area of El Progreso was estimated at about 194 per 1,000 in 1961 and 140 per 1,000 in 1970. The total population in the four villages was about 3,000 in 1969. A supplementary feeding programme was implemented in order to improve the nutritional status of the population. One of two types of supplement, a protein-calorie one (*atole*, a gruel made with milk and a vegetable protein, *incaparina*), or a calorie-only one (*fresco*, Spanish for a refreshing, cool drink) was provided in each of the four participating villages. The *fresco* contains one third of the calories of the protein-calorie supplement (59 calories compared with 163 calories per 100 millilitres). In addition, both include vitamins, minerals and fluorides limited in the home diet. Attendance at the supplementation centre in each village was voluntary, and there were no restrictions on quantity that could be ingested; therefore, a wide range of intake occurred. Supplement intake in the study was expressed in terms of calories because the normal dietary intake of the population appeared to be more limited in calories than in proteins.

No medical care services were included in the original experimental design, but a real and felt need for these was detected as the project progressed. Thus, a health care programme was implemented in each community, with attention provided by physicians. After thorough study, this system was simplified in such a way that the physician's role became that of supervisor for the auxiliary nurse who took charge of the primary care services.

A series of analyses were conducted before this modification was designed and implemented. Once the medical care needs were defined in terms of quality and quantity, the record of cases attended in the clinics was examined. The analyses of 2,287 patient visits to the clinics in the four communities indicated that the most frequent causes for patient visits were dermatological, gastro-intestinal and respiratory problems. The treatment of these cases is relatively simple and thus could be delegated to intermediate health personnel. The analyses coincided with the opinion of the medical personnel working in the project, who felt that they were being underutilized. Finally, the cost aspect of the medical care programmes was also analysed.

Based on the above, a simplified health care programme was begun. Curative care was emphasized using a simplified therapeutic guide. This guide provided the clinical symptoms of the most frequent diseases and indicated the appropriate treatment. The criteria for the selection of the medicines recommended were: relative harmlessness, effectiveness, ample therapeutic value, easy administration and low cost. Table 143 presents an example of the contents of the therapeutic guide.

Before the new programme was implemented, aspects related to the health personnel required were studied. Of the various alternatives reviewed, the auxiliary nurse was chosen to be trained as the medical auxiliary in charge of primary care in the out-patient clinics. The use of nursing auxiliaries in this way is not in itself particularly innovative. Auxiliaries have traditionally provided some form of health care to rural populations in developing countries. For example, in Guatemala, auxiliary nurses typically receive hospital training and are

TABLE 143. ILLUSTRATIVE PAGE OF THERAPEUTIC GUIDE PREPARED FOR THE GROWTH AND DEVELOPMENT PROJECT, GUATEMALA

01. Respiratory System (example)					
			Treatment		
History	*Physical Exam*	*Diagnosis*	*Adults*	*Children*	*Observations*
Nasal discharge, sneezing, fever, head and body aches, sore throat, general malaise, anorexia. Occasionally accompanied by cough, vomiting and eye irritation. (In cases of acute bronchitis cough is frequent.)	Examine mouth, nose and auscultate lungs. Nasal mucus, redness and congestion are commonly encountered on examination. Generally the lymph glands in the neck area are enlarged and painful. Mild fever. The following vital signs should be recorded: oral temperature, pulse.	*Upper Respiratory Infection* Code: 0101 (Includes a series of infections which affect the upper respiratory tract including bronchial passages).	(1) Drink abundant liquids, i.e., lemonade, orangeade, etc. (2) *Aspirin:* 1 tablet p.o. every 4 to 6 hours during 2 days when fever is present. (3) In case of gastritis give *Acetominophen* 1 tablet p.o. every 4 to 6 hours × 2 days instead of aspirin. (4) When cough is present give *expectorant* 1 teaspoonful every 4 to 6 hours for 3 days.	(1) Drink abundant liquids. (2) *Aspirin:* according to weight for 2 days in case of fever. (3) Cough syrup: ½ to 1 teaspoonful every 4 to 6 hours for 3 days in case of cough.	Upper respiratory infections can become complicated. The most frequent complications are lower respiratory infections, otitis, sinusitis and pharyngeal tonsilitis.

NOTE: The remaining segments of the therapeutic guide are similar to this example.

subsequently employed in rural clinics administering medicines prescribed by the physician, although they lack formal training in diagnostic or therapeutic techniques.

In the simplified health care system described here, the auxiliary nurses were trained to take clinical histories, to conduct simple physical examinations and to diagnose and treat the most common diseases. This training was carried out in the clinic, with the first phase being the mastery of the therapeutic guide. Next the auxiliary was allowed to attend patients with continuous supervision by a physician and an auxiliary nurse previously trained in the simplified health care programme. Constant quality control was also practiced.

In addition to the management of common diseases, the auxiliary nurses were responsible for the implementation of maternal and child care activities and vaccination programmes. Diphtheria, whooping cough, tetanus and measles inmunization, BCG (tuberculosis), and protection against poliomyelitis were part of the services offered to preschool children. Because in one community five of twelve newborn infants died during early stages of programme implementation, a tetanus immunization programme was initiated for pregnant women, newlyweds and all other women of marriageable age.

The Sololá Project

In October 1976, in conjunction with the Ministry of Public Health and Social Welfare of Guatemala, an integrated primary health care programme was begun. The programme included aspects of curative medicine and health promotion. The project was conducted in four Indian communities in the Department of Sololá, from which the project took its name, and covered a population of approximately 5,500 inhabitants. The child mortality rates in Sololá were among the highest of all departments, with little evidence of decline between 1961 and 1970 (see table 141).

The project personnel included a physician-supervisor and four auxiliary nurses, one in each community. After a baseline study in which survey and anthropological (ethnographic) data were collected, programme planning was begun. The communities participated from the onset. In each community the formation of a health committee was promoted. The committees were composed of representatives from each of the organized groups existing in the communities (social, political, religious, athletic etc.). One of the committees' first activities was the selection of local candidates to be trained in curative and preventive medicine and health promotion services. Sixteen health promoters were chosen from the four communities. Only two of these were women.

A work group of the Institute of Nutrition of Central America and Panama (INCAP) took charge of the preparation of manuals and guides for personnel training and for service delivery, as well as the training of a medical supervisor and the programme's auxiliary nurses. After two months of training, the medical and auxiliary personnel began, in turn, to train the health promoters and empirical midwives. The training was initially focused on curative aspects, since "to cure sick persons" was defined as the first priority by the health committees and was also the principal interest of the promoters at the beginning of the programme. The committees also considered it important that all services, examinations and medicines be free, and that the health promoters receive a scholarship to compensate for the time and income forgone from their normal agricultural activities.

The promoters were trained in nursing techniques such as clinical examination of patients, disease diagnosis and treatment of patients under constant supervision by the auxiliary nurse and physician. All aspects of training were detailed in the operations manuals prepared specifically for this project. These included the clinical examination manual, the simplified therapeutic guide, preventive health care etc. This material constituted a valuable resource for health personnel formation. The promoters were also trained to conduct activities in health service extension. They made periodically programmed home visits to detect disease, to provide patient follow-up and to perform health promotion activities. The sectorization of the communities and the selection of health guardians was successfully accomplished and had the communities' dedicated support.

The auxiliary team, health promoters and auxiliary nurses were also responsible for the vaccination of preschool-aged children and pregnant women according to the norms defined in the preventive medicine protocol. During the first year of work, epidemics of communicable gastro-intestinal and respiratory diseases were detected. Education campaigns were carried out for groups and individuals regarding recommended techniques for disease prevention. Co-operation from local authorities was obtained in order to use the *pregón*, the traditional communications system dating from the colonial era, in which town criers repeat a message of general interest at the corners of all the town's main streets.

Specific messages on hygiene and environmental sanitation were also transmitted by the promoters during biweekly home visits. Group meetings were held at the health posts, with different sectors of the population being invited periodically to participate in presentations and discussions of topics of their interest. Meetings were held for the total population where educational and entertaining movies were shown, with subsequent discussion of the most relevant aspects.

With regard to maternal health care, activities initially focused on the study of natality and mortality information from each community's municipal records, and the identification of existing empirical midwives. Expected high birth and death rates were confirmed. The health personnel established informal relationships with the traditional midwives. Their knowledge, attitudes and practices were studied and classified into three categories: acceptable, unacceptable and harmless. The results, shown in table 144, indicate that given the circumstances and resources, the midwives tended to use acceptable or harmless techniques (Hurtado, 1982). The unacceptable techniques, rare for these midwives, were analysed together with the auxiliary personnel in order to demonstrate to the midwives the risks involved. The

TABLE 144. BENEFICIAL, HARMLESS AND HARMFUL PRACTICES OF TRADITIONAL MIDWIVES IN SAN PABLO LA LAGUNA, SOLOLÁ, GUATEMALA, 1976-1977

Beneficial	*Harmless*	*Harmful*
Respond and arrive promptly in times of need	Require umbilical cord to be of certain length	Fail to use aseptic procedures and material in delivery care of newborn
Create atmosphere of trust and confidence	Require proper disposal of the placenta	Perform strong abdominal massages
Recognize mother's and baby's need to be together	Administer ritual baths to mother and infant three days post-partum	Tie sash around woman's abdomen to hasten delayed delivery
Recognize need for other family members to be present at childbirth.	Share and respect woman's modesty in child-bearing matters	Hold woman upside down by her feet to correct abnormal fetal presentation
Attend to mother and family for long period after birth		Restrict intake of "cold foods" (fish, pork, fruits) in post-partum period
Remain with women during labour; do not force women to bear down too early		Refrain from referring patients to hospital in case of emergency
Allow women to move, sit and walk during first stage of labour, and to assume squatting position for delivery		Advise giving infant sweetened water until mother's milk "comes down"
Support women psychologically and emotionally; maintain close personal relationship with them		

actual death of a mother during childbirth in a neighbouring community, which was attributed to inadequate care of a full-term pregnancy with the child in transverse position on the part of an inebriated midwife, served as the basis for a series of discussions with the midwives. Formal teaching was avoided as much as possible, with informal talks over a cup of coffee being preferred. As a result of the analysis of the existing problems and of the information obtained from the midwives and the community, a simplified prenatal care manual was prepared which emphasized the concept of high risk and the levels of prenatal, delivery, post-partum and perinatal care.

As an extension of maternal care, a study of knowledge, attitudes and practices of family planning was conducted. It was found that the communities had some knowledge of contraceptive methods but most eligible persons had never used any method. The few women who had had contact with modern contraceptive methods, such as the pill, had received little information and thus the method had been used inadequately. An example of this was a woman who distributed the pills from one cycle to all her good friends so that they too might receive the benefits of modern contraception.

Based on the existing demand, a family orientation programme was begun through which several contraceptive methods were made available to the community. The community was informed of the availability of the methods and a group of interested persons (mostly women) were instructed in their use. It was evident that a large unsatisfied demand existed; once available the women began to utilize these methods even when they had to buy them at moderate prices in the health posts.

The first activities undertaken in terms of infant and preschool child care were aimed at early detection and treatment of malnutrition. Thus, the promoters and auxiliary nurses were trained to obtain anthropometric measurements (height or length and weight) from children 5 years of age and under. Those cases in which the weight-for-height relationship was less than 80 per cent of the standard were detected and treated on an out-patient basis by the daily provision of a milk and *incaparina* preparation at the health post level. At each visit to the health post the mother or person in charge of the child received nutritional education.

The child's anthropometric information was contained in a health card which was given to the mothers of all children 5 years of age or under residing in these communities. The health card contained a weight-for-height graph in which the mother could appreciate her child's nutritional status as a point in the graph and follow his/her recuperation or normal progress. Also included in the health card was information such as the child's identification, vaccination history, disease history and growth and development. At each visit to the clinic the auxiliary or the promoter would examine the card and bring it up to date with that visit's findings.

The Patulul Project

In October 1977, the Patulul project was officially begun in the Department of Suchitepéquez, Guatemala. The child mortality rates in the rural areas of this Department were 172 and 171 per 1,000 in 1961 and 1970, respectively (see table 141). The project covered a total population of 7,166 persons residing in 12 coffee plantations whose individual populations varied from 289 to 1,398 inhabitants. The project included aspects of curative and preventive medicine, and nutritional interventions designed to increase the availability of calories and/or proteins at the family level. The project's experimental design required two years of baseline studies, including health care, prior to the beginning of the nutritional interventions. During the first two years, a series of health activities were developed whose results are summarized in this section.

Prior to the initiation of the specific activities of the project, a baseline study was conducted. This consisted of a census and the collection of economic, social, cultural and demographic data for each family; furthermore, anthropometric information was collected for children under 5 years of age. The results indicated the existence of high mortality (for example, infant mortality was 160 per 1,000), fertility (crude birth rate of 50 per 1,000) and malnutrition (47.5 per cent of children under 5 years of age had less than 75 per cent adequacy of weight for age) rates.

Based on the information obtained, planning for a simplified health care programme utilizing paramedical personnel (rural health promoters and auxiliary nurses) with medical supervision was begun. With co-operation from the plantation owners and managers, members of the community were selected for training as rural health promoters. All the selected personnel were female.

Specific manuals had been prepared previously for personnel training and for curative and preventive service delivery. The training of auxiliary nurses was accomplished over a two-month period and they were, in turn, responsible for training the promoters. Training of the latter was carried out on the job so that from the very beginning they learned the nursing skills and techniques necessary for examination, diagnosis and treatment of patients in each plantation's health post.

The guides and manuals such as the therapeutic guide, which included information on the signs, symptoms and treatment of common diseases in the rural area, which were prepared for this project, were ideal education materials for personnel training. Initially, the personnel were more interested in diagnostic and therapeutic aspects. Once they had learned to cure they were very receptive to learning to prevent.

Rigorous quality control was maintained in all aspects of curative medicine. The physician examined a percentage of all patients simultaneously with the auxiliary nurse or promoter, enabling him or her to detect errors and retrain personnel. The use of precoded forms was also very useful for quality control procedures.

With regard to preventive medicine, an intense vaccination programme was developed which eliminated epidemics such as measles, which had previously affected large segments of the population. The vaccination coverage for measles, DPT and polio was consistently above 80 per cent in the susceptible groups. Furthermore, routine vaccination of pregnant women with tetanus toxoid was practiced to avoid the risk of neonatal tetanus.

An environmental sanitation programme was begun as part of the preventive activities. This included improvement of water supplies and quality, and latrine installations. Bacteriological analyses of water demonstrated that it was highly contaminated in all plantations. Also, studies of the existing systems revealed that sufficient water was available but that the process by which it was conducted, stored and distributed was inappropriate. Given these findings, specific projects utilizing simple models for an adequate hygienic process were prepared for each plantation. The simplicity and low cost of these projects stimulated the plantation owners to improve water quality. The latrine programme made use of the idea of demonstration projects. Thus, 10 per cent of the population, the most co-operative families, were the first to receive latrines. This 10 per cent learned to utilize the latrines properly and stimulated the other 90 per cent to request unifamily latrines also. The latrines were adequately maintained and used appropriately.

In the maternal care programme, early pregnancy detection, prenatal care, determination of delivery risk level and post-partum and perinatal care were emphasized. The empirical midwives were identified and trained in informal settings. Special emphasis was given to childbirth management and care of the newborn. The midwives were trained to obtain birth weights using a simple scale, and to refer high-risk cases. At the clinic level, fetal growth was monitored by means of uterine height, and external manipulation was practiced in the third trimester when the fetus was in transverse position. Great attention was focused on defining the risk level of each pregnancy in order to decide the level of care necessary at delivery. Furthermore, breast-feeding was promoted; in cases of failure to breast-feed, various methods were used to stimulate milk production and continue nursing, including traditional herbal remedies.

Infant and preschool child care programmes were aimed at early detection of cases of protein-calorie malnutrition. Malnutrition cases with weight-for-height of less than 80 per cent of standard were treated on an outpatient basis using *incaparina* or milk until adequacy above 80 per cent was reached. Anthropometric data was contained in each child's health record in which his/her identification, measurements, vaccinations, diseases and growth and development findings were recorded. It is important to note that in cases where children under 6 months of age were found to be malnourished, the supplement was provided to the nursing mother.

Results

The impact of these projects can be measured in terms of the demand for the services, effects on mortality, effects on nutritional status and side effects.

The demand for services was measured by the number of visits per person per year to the health post. The median number of visits per person per year in the Growth and Development and in the Patulul projects were between 3 and 4.

A much lower number of visits to the clinic was observed in the Sololá project. From 1 October 1977 to 30 September 1979, a total of 3,163 patients (from a population of around 5,500) were treated in the clinics of the four communities covered by the Sololá Project. However, available information indicates that before the project started the largest town (with 2,865 inhabitants in 1977) had an average of approximately 260 visits per year, which is considerably lower than the 1,422 cases seen in that town during the project's second year. Furthermore, the analysis of one trimester of information indicates that a significant portion (43 per cent) of the cases were treated by promoters at both the home and clinic levels nine months after the project was begun. This figure increased as the promoters gained skills through training and were given new responsibilities. The home visits not only reduced the number of visits to the clinics but also facilitated the promotion of the preventive medicine programme, which attained coverages of over 80 per cent for DPT, polio and measles vaccinations during the course of the project.

The majority of cases were attended by auxiliary personnel in all projects. For example, after the first nine months of the Patulul Project, of 5,207 patient visits during the July-September 1978 trimester, 350 (6.7 per cent) were seen by the physician, 1,536 (29.5 per cent) by the auxiliary nurse, and 3,321 (63.8 per cent) were attended by the health promoters. The majority of cases attended by the physician were those referred by paramedical personnel or seen during quality control examinations.

The effects of the three projects in terms of infant and preschool mortality were also very positive. Table 145 presents the impact of the Patulul Project's simplified health care programme on the mortality rate. According to information obtained from pregnancy histories for the 1970-1975 period, infant mortality was approximately 160 per 1,000 live births. After two years of the project, during 1977-1978, this rate had declined to 90 per 1,000 live births.

TABLE 145. INFANT MORTALITY IN THE STUDY POPULATION OF THE PATULUL PROJECT

Before the programme, 1 October 1972-30 September 1977	*During the programme, 1 October 1977-30 September 1978*
(Infant mortality per 1,000 live births)	
160	90

A similar reduction in mortality rate was observed in the Sololá project, as shown in table 146. For infant mortality, before 1976 the rates were estimated by the project census and civil records. The other figures were obtained during the course of the project from several sources: the civil register, health post records and census at the home level. In spite of the fact that for Santa Cruz and Tzununá there was an obvious underreporting in the civil register's data prior to the programme's initiation, a decrease in mortality was observed in the first two years of the project.

TABLE 146. INFANT MORTALITY RATES PER 1,000 LIVE BIRTHS IN THE PROJECT VILLAGES BEFORE AND DURING THE SOLOLÁ HEALTH INTERVENTIONS

	Before interventions			*During civil register*
	Census		*Civil register*	
Villages	*1969-1970*	*1973-1974*	*1967-1976*	*1977-1979*
San Pablo	164	148	138	111
San Marcos	166	181	186	113
Santa Cruz	243	212	138	127
Tzununá	185	154		
TOTAL			146	116

A much more striking reduction in mortality was found in the longitudinal Growth and Development study, which, in contrast to the Sololá and the Patulul projects, included both health care and nutritional interventions. As shown in table 147, the decline in infant mortality which was occurring in three of the four villages even before initiation of the project became much more marked during the time of the interventions. Even in the village of Espiritu Santo, which recorded a mortality rise during the preceding years, infant mortality fell sharply during the interventions. The decline occurred during both the neonatal and post-neonatal years. According to data obtained from pregnancy histories for the 1960-1968 cohort, the neonatal mortality rate was 104.8 and the post-neonatal mortality rate was 47.0 per 1,000 live births. The stillbirth death ratio was 24.8 per 1,000 live births during the same period. For the 1969-1975 cohorts the corresponding figures were 24.1, 32.2 and 21.7 per 1,000 live births, respectively. Information recently collected in the four communities, after the health and nutritional interventions took place, revealed that total infant mortality continued to be low, 27 per 1,000 live births, for the 1977-1980 period.

TABLE 147. INFANT MORTALITY RATES PER 1,000 LIVE BIRTHS IN FOUR LADINO GUATEMALAN VILLAGES BEFORE, DURING AND AFTER THE HEALTH AND NUTRITIONAL INTERVENTION OF THE GROWTH AND DEVELOPMENT PROJECT

		Villages				
Period	*Health and nutritional intervention*	*Santo Domingo*	*Espiritu Santo*	*Conacaste*	*San Juan*	*Total*
1960-1963	Before	137	110	209	162	162
1964-1968	Before	83	160	125	131	124
1969-1972	During	70	77	39	109	69
1973-1976	During	53	18	91	37	54
1977-1980	After	26	31	33	15	27

In all these projects, the reduction in mortality rates could be attributed to the curative and preventive health care programmes, given that no other intervention was concurrently instituted in these communities. Moreover, the greater reduction in mortality rates observed in the Growth and Development Project could be partially due to the nutritional intervention, especially to the food supplements consumed by mothers and infants. As shown in table 148, improved maternal nutritional status during pregnancy, particularly during the first trimester of pregnancy, prolonged the length of gestation and increased the birth weight of the newborn.

TABLE 148. PERCENTAGE OF NEWBORNS WITH LOW BIRTH WEIGHT (≤2.5 KG) AND SHORT GESTATIONAL AGE (<37 WEEKS), BY TERCILES (LOW, MIDDLE, HIGH) OF SUPPLEMENT INTAKE DURING THE FIRST TRIMESTER OF PREGNANCY

	Low	*Middle*	*High*	*Significance level*
	percentage			
Low birth weight (≤2.5 kg)	18.7	9.9	12.8	< .05
Short gestational age (<37 weeks)	18.2	11.1	4.1	< .001
Low birth weight and/or short gestational age	32.5	11.5	15.0	< .001
(Sample size)	(203)	(252)	(266)	

Figure XII shows that newborns weighing less than 2,500 grams have an increased risk of neonatal and post-neonatal death. Similarly, the risk of neonatal and post-neonatal mortality decreases with the length of gestation (figure XIII).

Figure XII. Stillbirth death ratio and neonatal and post-neonatal mortality rates by gestational age, 1969-1977 birth cohorts

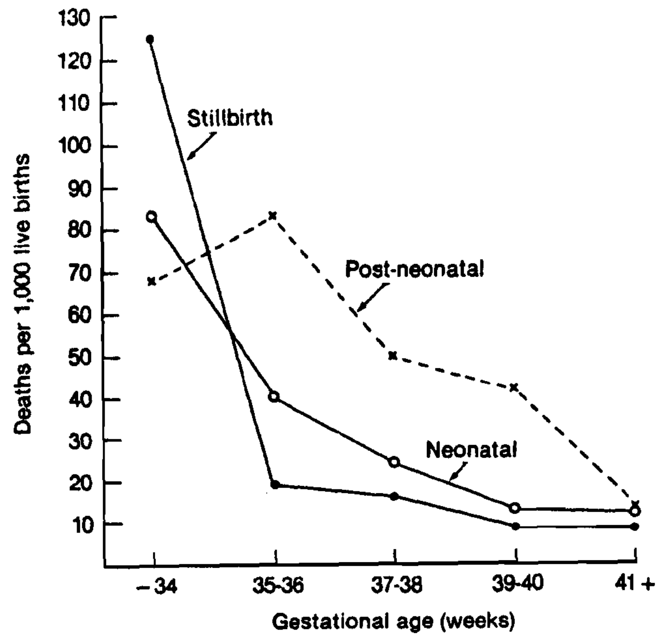


Figure XIV. Infant mortality rate by categories of gestational age and birth weight

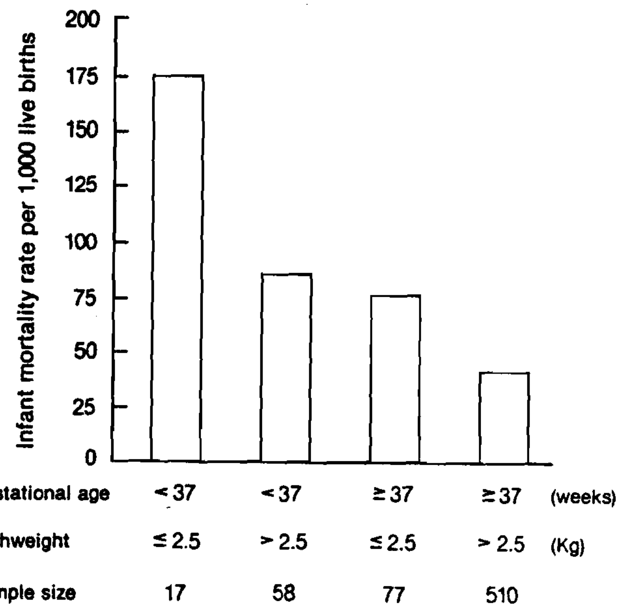
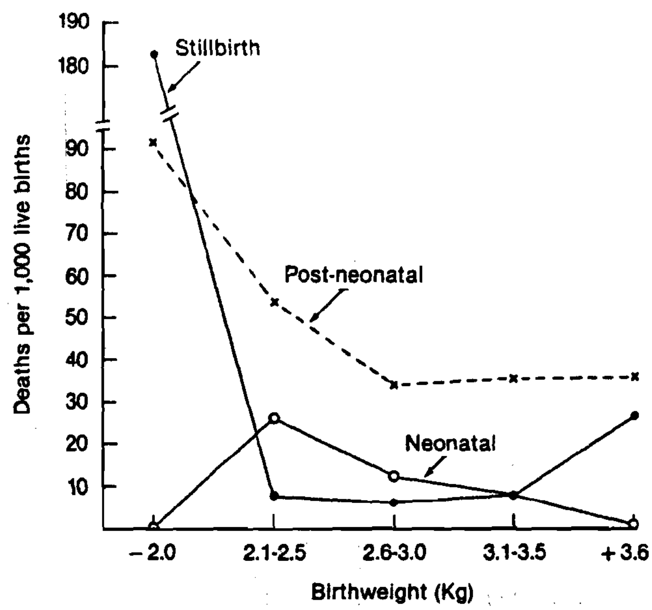


Figure XIII. Stillbirth death ratio and neonatal and post-neonatal mortality rates by birth weight, 1969-1977 birth cohorts



The combined effects of gestational age and birth weight are presented in figure XIV. As shown in this figure, those infants with low birth weight and short gestational age had the highest mortality rate, 176 per 1,000 live births, while those with normal birth weight and gestational age had the lowest, 41 per 1,000 live births.

The food supplementation ingested by the mother during the first nine months of lactation was also significantly and positively associated with the length of lactation. Therefore, the improved nutritional status of the mother during lactation could also have contributed to the observed decline in infant mortality rates. In fact, in spite of the diminishing contribution of breast-milk to the infants' nutrient intake, lactation continues to be an important determinant of infant growth in this population up to 18 months of age.

Figure XV presents the weight-for-age figures of a cohort of children who were followed from birth to 24 months of age. For each semester, data on children who were still breast-feeding, who were being weaned and who were already weaned are presented. These data show that up to 18 months of age weaned children weighed consistently less than those who were in the process of weaning, and the latter significantly less than those who continued to breast-feed. These figures also show that growth failure began before weaning took place, suggesting the presence of maternal and child factors which may precipitate weaning.

In addition, the data indicate that infant food supplementation after 3 months of age is significantly and positively associated with infant weight and length gains. Therefore, infant supplementation could also be responsible for the observed decline in mortality.

It is likewise possible that available health services in the Growth and Development Project were utilized more timely than those rendered in the other two projects implemented in Indian communities. The vicinity of the health centre to the food supplementation centre could have been a reason for the higher and more opportune demand for services in the project implemented in the Ladino population.

Analysis of the morbidity data collected every two weeks for each family residing in the Patulul plantations and the information on the visits to the clinic indicate that health services were not properly utilized. As shown in figure XVI, at the community level the number of visits to the clinic for gastro-intestinal disorders in children below 5 years follow the shape of the curve of

Figure XV. Weight of children before, during and after weaning, as compared with National Centre for Health Statistics reference

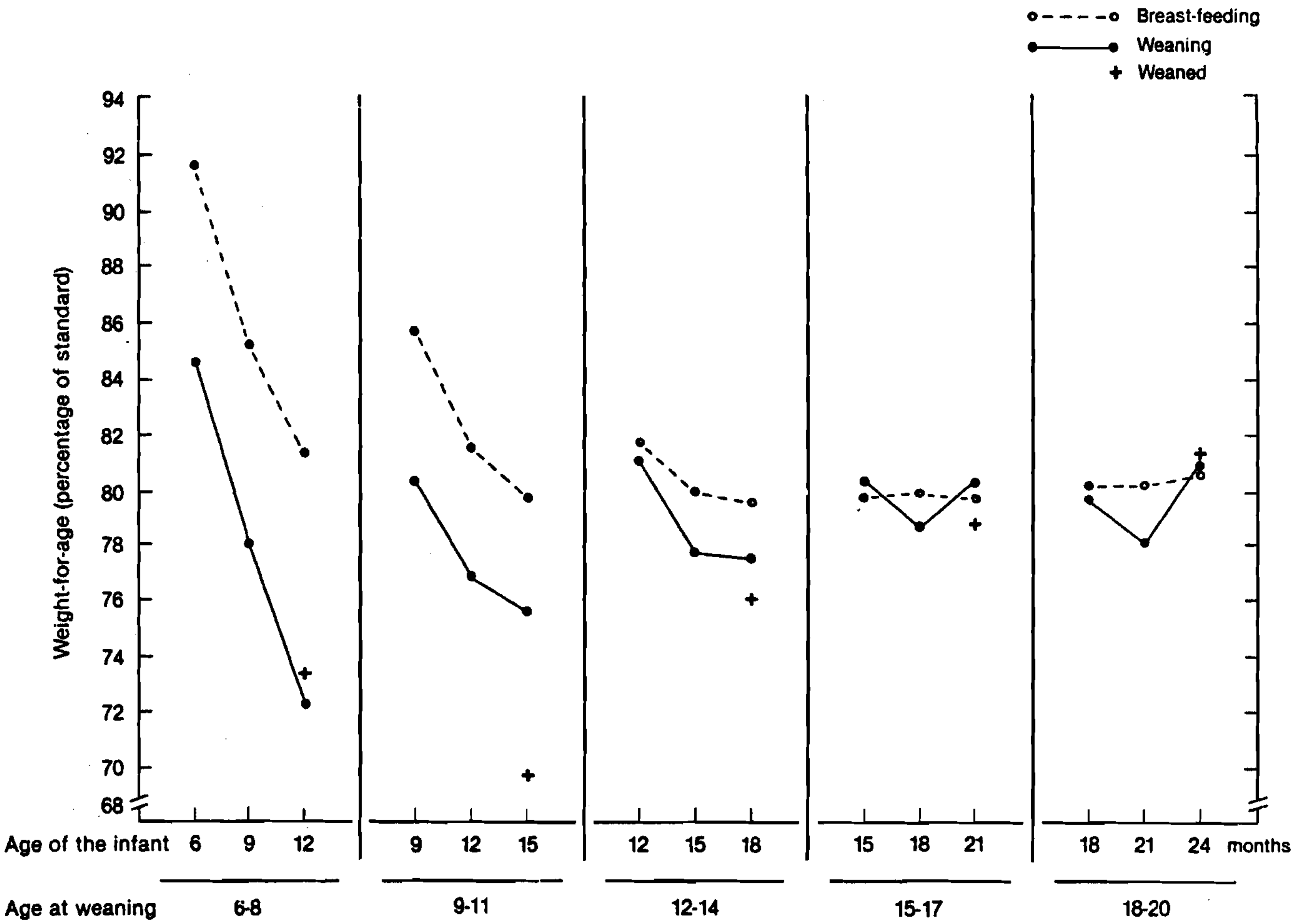
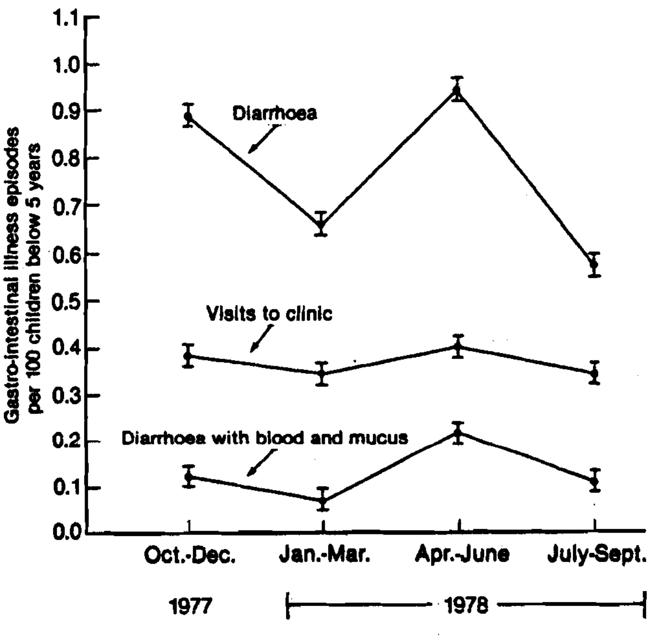


Figure XVI. Gastro-intestinal illness episodes and average number of visits to the clinic for gastro-intestinal disorders per trimester



Note: I Denotes mean ± its standard error.

reported illness episodes, that is, simple diarrhoea and diarrhoea with blood and mucus. However, as shown in figure XVII, when the data were analysed at the individual level, it was found that all conditional probabilities of demand for services given a gastro-intestinal illness episode, per trimester, were below 50 per cent.

As also shown, there are higher probabilities of demand for services for the more severe symptoms of gastro-intestinal disease, diarrhoea with blood and mucus, than for the more common symptoms, simple diarrhoea. In addition, sex differences were found: the conditional probabilities of visiting the clinic, given the existence of simple diarrhoea or diarrhoea with blood and mucus, were, with one exception, higher for boys than for girls. This difference is possibly related to cultural sex preferences.

In spite of the favourable opinions of the users of the Patulul health care programme, the previous results indicate that not all the families were utilizing the services properly. This suggests a differential impact of the project in different segments of the population, even though, as a whole, the infant mortality rates were clearly reduced.

The effects of morbidity and health services on the nutritional status of the children in the Patulul project were also examined. For these analyses, the dependent variable was the trimestral weight-for-age changes in

Figure XVII. Conditional probability of visiting the clinic, given a gastro-intestinal illness episode, per sex and trimester

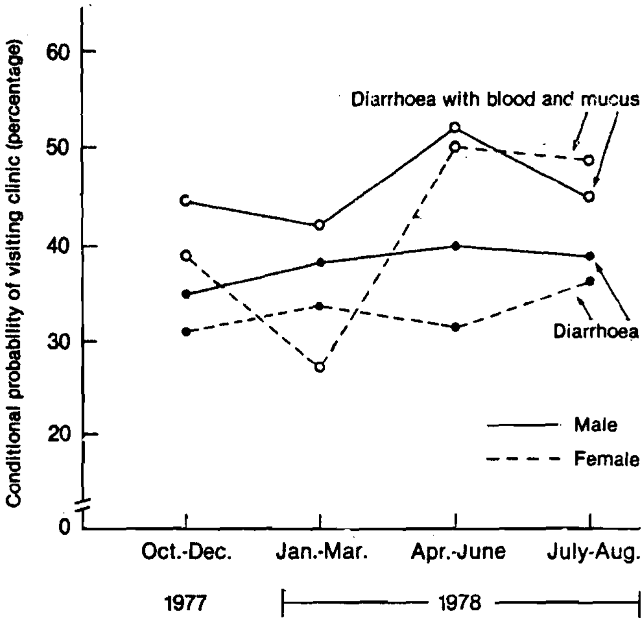


TABLE 149. TRIMESTRAL WEIGHT-FOR-AGE PERCENTAGE CHANGES IN CHILDREN 0-24 MONTHS OF AGE IN DIFFERENT CATEGORIES OF INITIAL PERCENTAGES OF WEIGHT-FOR-AGE, GASTRO-INTESTINAL DISORDERS AND UTILIZATION OF HEALTH SERVICES DURING THE TRIMESTER

Part A. Weight-for-age ≤ 75 percent of standard [a] at the beginning of trimester

	Gastro-intestinal disorders		
	Absent	*Simple diarrhoea*	*Diarrhoea with blood and mucus*
Total	4.74 ± 1.14 (51)[b]	1.03 ± 0.62 (104)	0.18 ± 1.18 (37)
No utilization of services ..		0.94 ± 0.76 (61)	−0.95 ± 1.64 (21)
Utilization of services		1.16 ± 0.50 (43)	1.65 ± 1.67 (16)

Part B. Weight-for-age > 75 per cent at the beginning of trimester

	Gastro-intestinal disorders		
	Absent	*Simple diarrhoea*	*Diarrhoea with blood and mucus*
Total	−3.25 ± 0.78 (148)[b]	−3.46 ± 0.59 (220)	−4.21 ± 1.21 (51)
No utilization of services ..		−4.12 ± 0.73 (135)	−4.09 ± 1.81 (30)
Utilization of services		−2.40 ± 1.00 (85)	−4.38 ± 1.44 (21)

[a] Degree II and III of Gómez classification.

[b] Mean ± standard error of the mean; in parentheses, number of cases.

children below 24 months of age, and the independent variables were the presence or absence of gastro-intestinal illness episodes (simple diarrhoea and diarrhoea with blood and mucus) in each trimester of the year and the demand for services for gastro-intestinal disorders in the same trimester. In addition, the analyses were performed for two categories of weight-for-age: less than or equal to 75 per cent of the standard and more than 75 per cent. These two categories were considered because a greater subsequent increment in weight-for-age was expected in those children with a lower initial attained value of weight-for-age than for those with higher initial attained values.

Table 149 presents the effects of gastro-intestinal illness episodes and visits to the clinic for gastro-intestinal disorders on trimestral weight-for-age changes. As shown in part A of table 149, children with initially low weight-for-age (≤ 75 per cent) and with diarrhoea during the trimester gained considerably less weight-for-age than children without diarrhoea during the trimester. Furthermore, children with diarrhoea who visited the health post gained more weight-for-age than those with diarrhoea who did not demand health post services. The effects of diarrhoea with blood and mucus on trimestral weight-for-age changes and those of the health services were similar. On the other hand, as shown in part B of the table, children with initial high weight-for-age adequacy (> 75 per cent) and with diarrhoea or diarrhoea with blood and mucus lost more weight-for-age than those without diarrhoea. In the same category, those children taken to the health post for simple diarrhoea also lost less weight-for-age than those who did not visit the clinic. No effects of health services utilization on the weight-for-age changes in children suffering from diarrhoea with blood and mucus were detected. Similar results were obtained when length-for-age and weight-for-length were used as indicators of nutritional status.

These data suggest that diarrhoea and diarrhoea with blood and mucus and the utilization of health services affected the nutritional status of well-nourished children to a lesser degree than that of malnourished children at the beginning of the trimester. Similar trends emerged when trimestral length-for-age and weight-for-length changes per categories of initial length-for-age and weight-for-length were studied.

Furthermore, the health care programme and the nutritional programme had clear effects on the nutritional status of preschool children. At the individual level the results of the nutritional intervention can be summarized as follows. Greater supplement intake was clearly associated with better growth in supine length, arm length, weight and head circumference. Therefore, the supplements seem to have improved the variables indicative of linear growth and mass (Martorell, Klein and Delgado, 1980). At the community level, however, the long-term effects of the nutritional programme are not so clear. Figures XVIII and XIX show the three-year moving average of the proportion of children with weight-for-age deficits (< 75 per cent adequacy) and length-for-age deficits (< 90 per cent adequacy) in different years of the Growth and Development Project. In the three specific age and sex groups shown in these figures, the percentage of growth-for-age deficit diminished in the first three to four years of intervention, in both the children receiving caloric supplementation and those receiving protein-calorie supplementation. However, after the fourth year, the percentage of weight-for-age and length-for-age deficits began to increase again. The increment in the levels of the deficits could be partially due to a substitution in the diet and to the survival of malnourished children who would have died had health services not been available. Results from

Figure XVIII. Age-specific weight-for-age deficit in children participating in a health and nutritional intervention, males only

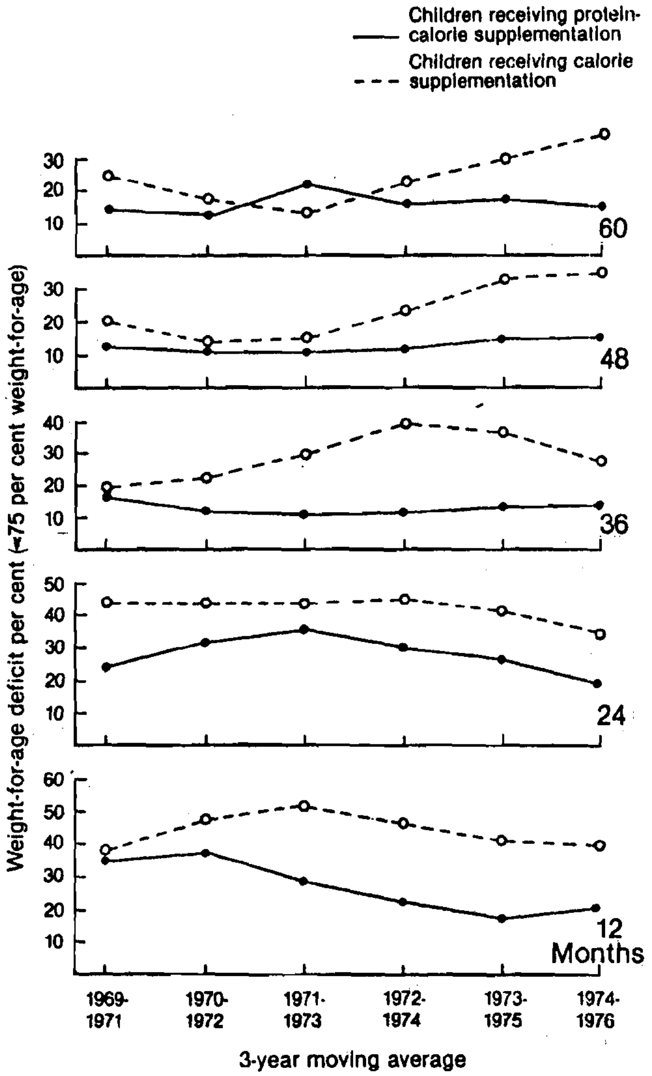
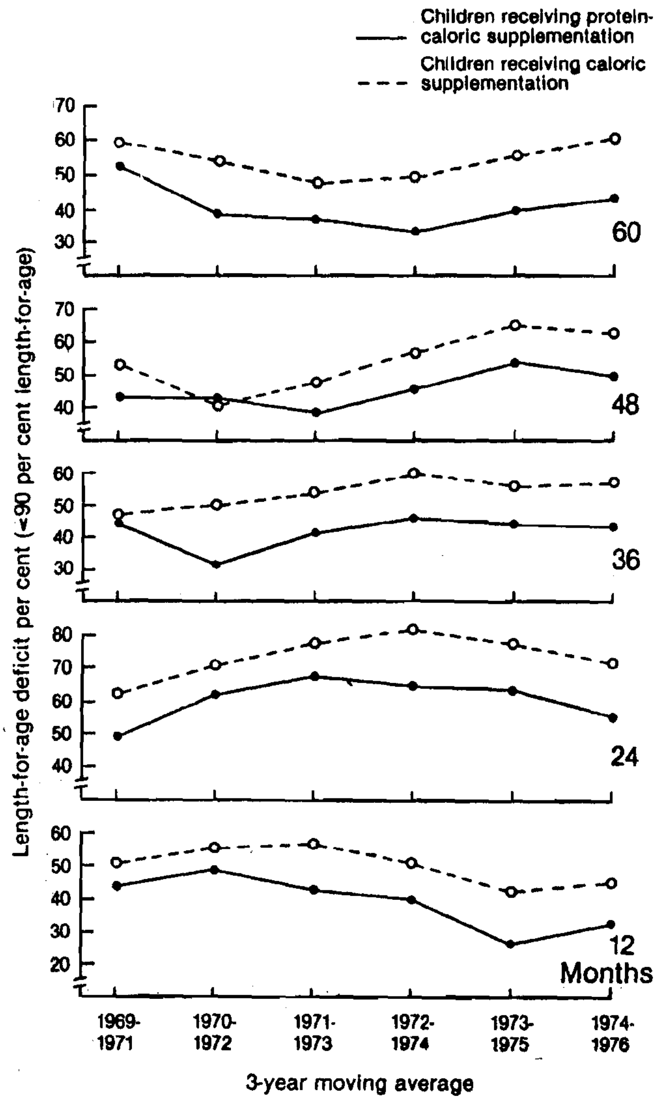


Figure XIX. Age-specific length-for-age deficit in children participating in a health and nutritional intervention, males only



the Patulul Project showing increments in the percentage of weight- and length-for-age deficits at specific preschool ages support the latter interpretation, suggesting that the results of a successful health care programme could be an initial increment in the percentage of malnourished children.

The immunization programme, particularly the tetanus programme for pregnant women, newlyweds and women of marriageable age, was also successful in the eradication of neonatal tetanus in the three projects. Most of the decline in neonatal mortality in the Growth and Development Project was due to a reduction in the mortality due to tetanus. In 1969, when the project began and the tetanus programme was implemented, out of 7 deaths during the neonatal period, 5 occurred during the first week and appeared clinically to be tetanus neonatorum. After 1969 very few cases of tetanus were reported in babies of mothers who did not accept the vaccination programme.

In addition to the impact of the programme and to programme characteristics such as personnel, training, quality control and patient satisfaction, the issue of cost is crucial. In the Growth and Development Project it was estimated that in 1972 the costs of the auxiliary nurses and of the supervising physician amounted to $US 0.92 per inhabitant per year. The project also dispensed gratis all medicines, a procedure that cost $US 1.34 per villager per year. Thus, the total cost per inhabitant was about $US 2.26 per year (Habicht, Guzmán and Reyna-Barrios, 1974). Originally, the same services were provided with the traditional physician-nurse work distribution, where the physician attended all patients without a therapeutic guide. Demands for medicines then exceeded the yearly medical supply budget of $US 2.38 per inhabitant, and salaries cost $US 2.25 per villager. In other words, the total cost then was more than double the expenditures in 1972.

Regarding the Patulul Project, the costs of personnel (health promoters, auxiliary nurses and supervising physician) were estimated in 1979 as $US 1.00 per patient visit and the cost of medicines as about $US 0.75 per visit to the clinic. Comparison of costs per out-patient visit in the government health services and in the Patulul

Project is not possible, due to the lack of reliable official data. It is interesting to note, however, that the costs per out-patient visit in the Patulul Project ($US 1.75) were lower than the average cost per out-patient visit estimated in 1972 for four private primary health care programmes working in Guatemala, and than the costs of the Growth and Development Project in 1972, when inflation is taken into account.

In summary, some results of three different health care projects that utilized a similar methodology have been presented. These projects had an important effect on infant mortality. Based on these data it has been estimated that the health care system using paramedical personnel, appropriate technology and strict quality control systems was mainly responsible for a decrement in infant mortality rates from 120 to 160 per 1,000 before the projects were implemented to about 80 to 90 per 1,000 during the first two years of the intervention period. The rest, from 80 per 1,000 to about 50 per 1,000 found in the Growth and Development Project, may be ascribed to the programme of food supplementation or, in other words, to the improvement of maternal and infant nutrition and to improved health care.

Given that the cost of the simplified health care programme is relatively low because it utilizes local paramedical personnel and maximizes the use of appropriate technology, it is a good means for improving the health situation prevalent in rural areas of Guatemala and other developing countries. This programme, however, should be complemented with educational activities, community participation and other development projects which foster better socio-economic conditions.

Causes of death and differentials in the Growth and Development Project

Causes. As mentioned earlier, of the 949 infants born between 1960 and 1968, before initiation of the Growth and Development Project, a total of 136 died before the first year of life, producing a stillbirth death ratio, neonatal and post-neonatal mortality rates of 24.8, 104.8, and 47.0 per 1,000 live births, respectively. In sharp contrast, the stillbirth death ratio and the neonatal and post-neonatal mortality rates of those born during the health and nutritional interventions, that is, between 1969 and 1975, were 21.7, 24.1, and 32.3, respectively.

Information about the causes of death from 1969 on was gathered monthly from the health post records in each of the four villages. These data are very incomplete, particularly during the neonatal period. Most of the difficulties in collecting information on the causes of death in these villages stemmed from the fact that very few of the children who subsequently died received health care during their final illnesses.

As shown in table 150, a total of 69 infant deaths were investigated under this study and their underlying causes of death were explored. Neonatal mortality was divided into two components: (*a*) mortality in the first week of life (early neonatal mortality), and (*b*) mortality during the remainder of the first month of life. The relatively small number of deaths do not permit broad generalization, but it may be observed in this table that the main causes of deaths during the early neonatal period were tetanus, immaturity and birth injury. The main cause of death in infants 8 to 28 days of age was tetanus. As mentioned above, the strengthening of the programme for tetanus inmunization of pregnant mothers practically eradicated tetanus neonatorum after 1969. During the post-neonatal period the most common causes of death were those closely associated with the environmental conditions prevailing in these villages. Gastro-enteritis, acute respiratory infections and nutritional deficiencies were among the leading causes of death in this age group.

Differentials. Several biological and socio-economic factors appeared associated with the mortality rates both before and during the intervention period. Moreover, among some groups of infants the mortality decline between the periods 1960-1968 and 1969-1975 appears to be more evident. A description of infant mortality differentials before and during the intervention follows.

TABLE 150. NEONATAL AND POST-NEONATAL DEATHS, BY CAUSE OF DEATH AND AGE FOR BOTH SEXES COMBINED

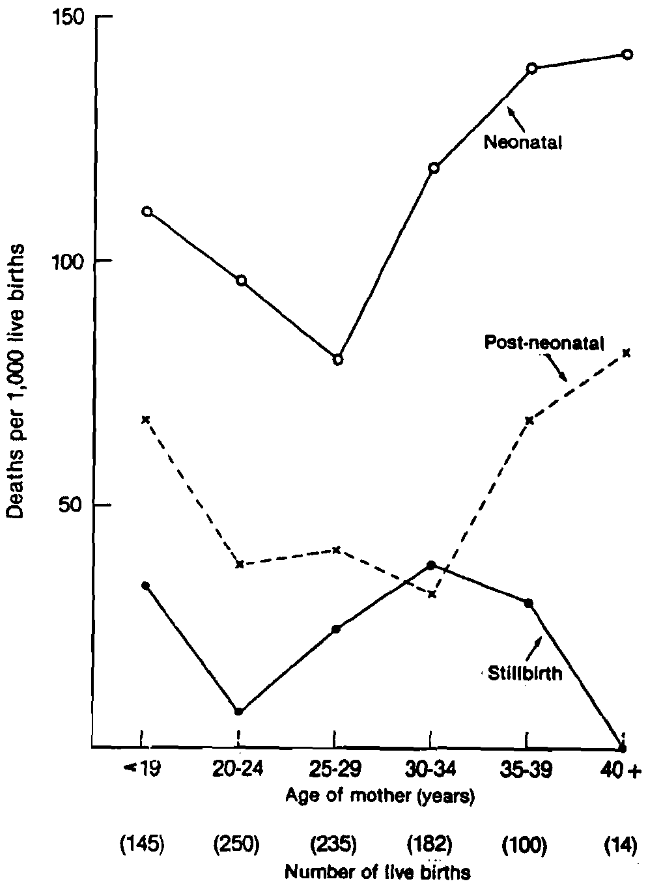
Growth and Development Project, 1969-1975

	Neonatal deaths			*Post-neonatal deaths*		
Causes	*1-6 days*	*7-27 days*	*28 days-2 months*	*3-5 months*	*6-8 months*	*9-11 months*
Tetanus	4	3	1	-	-	-
Immaturity	2	-	-	-	-	-
Acute respiratory infections	-	1	2	2	2	2
Enteritis and other diarrhoeal diseases	1	1	2	5	3	1
Congenital anomalies	1	1	-	-	-	-
Birth injury	2	-	-	-	-	-
Heart disease	-	-	1	-	1	1
Septicaemia	1	-	-	-	2	-
Disease of blood	-	2	-	-	1	-
Protein-calorie malnutrition	-	-	-	2	2	-
Unknown	7	4	3	3	3	-
TOTAL	18	12	9	12	14	4

NOTE: Hyphen = no deaths.

Age of the mother. According to pregnancy histories, between 1960 and 1968, the stillbirth death ratio and the neonatal and post-neonatal mortality rates were higher at the two extremes of the maternal age range (see figure XX); the rates were lowest during ages 20 to 29).

Figure XX. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by age of mother at birth of child; 1960-1968 birth cohort



The U-shaped pattern just described from the retrospective mortality estimates (1960-1968) was not observed for the stillbirth death ratio and the neonatal mortality rate during the intenventions (see figure XXI). During the 1969-1975 period, the stillbirth ratio was consistently low under age 35 and increased sharply thereafter. The neonatal pattern was just the opposite, highest in infants of mothers younger than 20 years of age and lower and relatively constant afterwards. Post-neonatal mortality exhibited the usual U-shaped pattern.

The mortality rates by maternal age group of infants born during the intervention period were consistently lower than the mortality rates of infants born before the intervention took place (see figure XXII). The highest drop in mortality occurred in the 30-34 year maternal age group; the mortality rates at the two extremes of the maternal age range were about half of those found before the intervention.

Birth order. As shown in figure XXIII, during the 1960-1968 period the highest stillbirth death ratio and neonatal and post-neonatal mortality rates were found among offspring of high birth orders and, to a lesser

Figure XXI. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by age of mother at birth of child, 1969-1977 birth cohorts

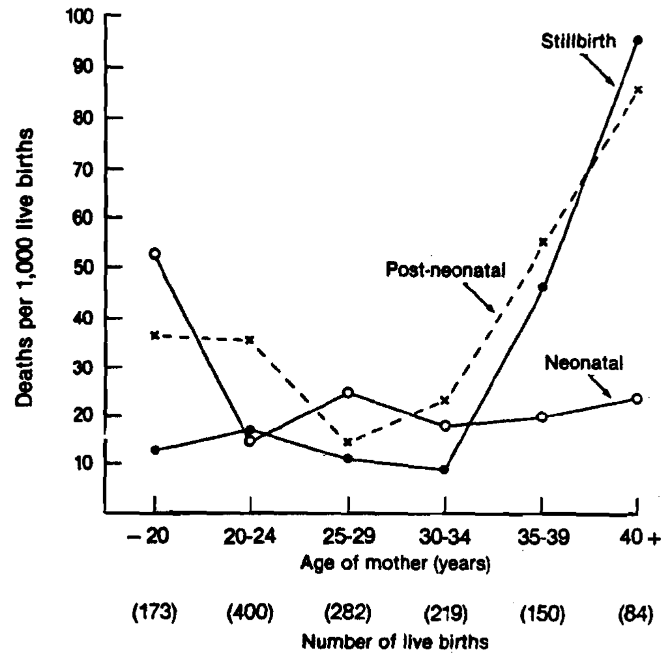
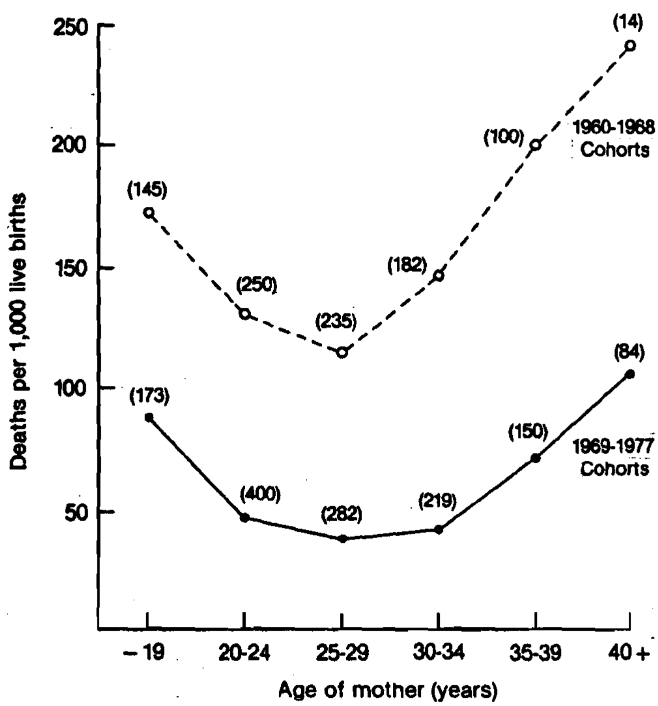


Figure XXII. Infant mortality rates for the 1960-1968 and 1969-1977 birth cohorts, by age of mother at birth of child



NOTE: ( ) denotes number of live births.

extent, first births. A similar pattern was observed in the mortality rates for the prospective data (figure XXIV).

Figure XXV illustrates the decline in infant mortality by birth order during the intervention period as compared with the retrospective information. The graph

Figure XXIII. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by birth order, 1960-1968 birth cohorts

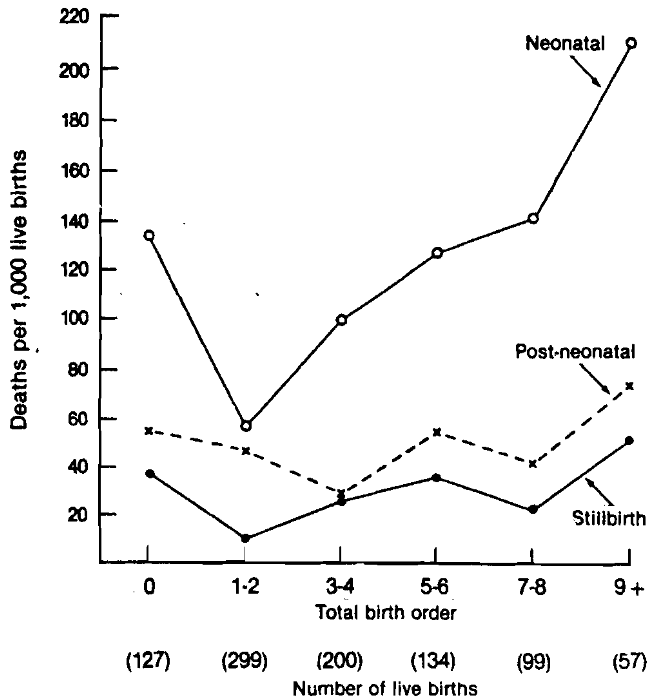
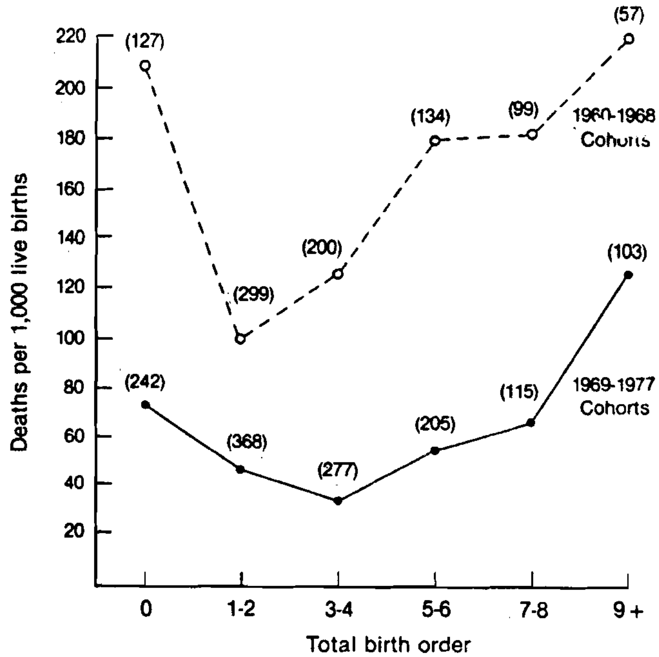
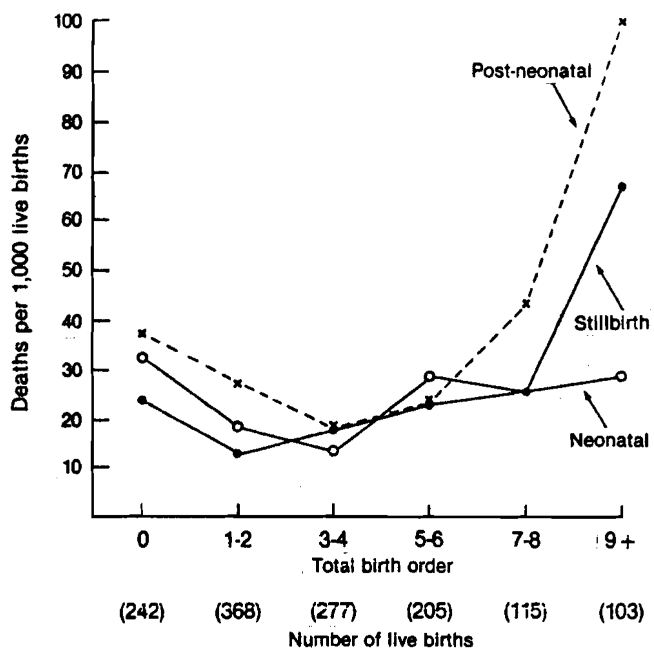


Figure XXV. Infant mortality rates for the 1960-1968 and 1969-1977 birth cohorts, by birth order



NOTE: ( ) denotes number of live births.

Figure XXIV. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by birth order, 1969-1977 birth cohorts



lines for infant mortality rates by birth order, for both before and during the interventions, run nearly parallel to each other. The highest reduction in mortality rates occurred among infants who were fourth or fifth in order of birth; that is, among offspring of mothers who had had three or four previous deliveries. An important reduction in infant mortality was also observed for first-borns and for children born sixth or seventh in a family.

Previous birth interval. Both before and during the interventions, the neonatal and post-neonatal mortality rates were higher when the time since the previous birth was less than 18 months than when it was between 18 and 36 months. Infant mortality rates were also particularly high among those born after an interval of more than 36 or 48 months (see figures XXVI and XXVII). The health care interventions appeared to benefit most the offspring born after an interval of more than 48 months or between 18 and 29 months.

Maternal and paternal education. The stillbirth death ratio and the neonatal and post-neonatal mortality rates, by maternal and paternal education level, for infants born between 1960 and 1968 are shown in figures XXVIII and XXIX, respectively. Contrary to all expectations, parents with four or more years of education had the highest infant mortality rates, followed by those with one to three years of education, and, finally, by those with no education. After initiation of the interventions, no clear relationship between parents' education and infant mortality appeared (see figures XXX and XXXI). Figures XXXII, XXXIII and XXXIV show that those who experienced the greatest decline in infant mortality rates after the interventions were the infants of the more educated mothers and fathers.

The reasons why mortality rates were higher for infants of more educated parents than for those of parents with less formal education in the 1960-1968 cohorts are not clear. It can only be postulated that the more educated couples living in poor villages, such as those studied in the Growth and Development Project, were in some ways less adapted to the prevailing environmental conditions. However, once health and other services became available, they were better prepared to obtain

Figure XXVI. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by previous birth interval, 1960-1968 birth cohorts

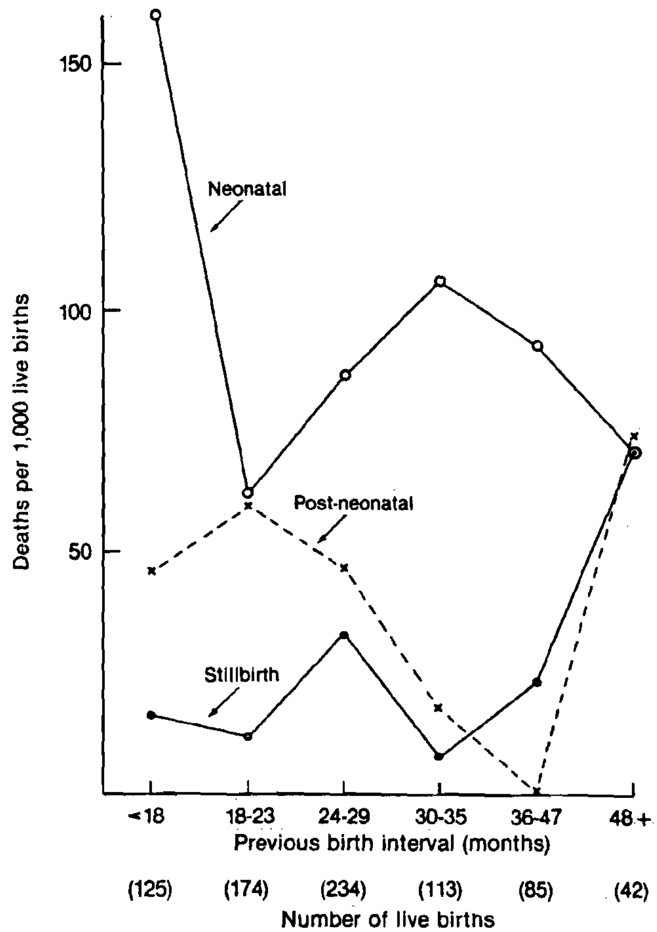


Figure XXVII. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by previous birth interval, 1969-1977 birth cohorts

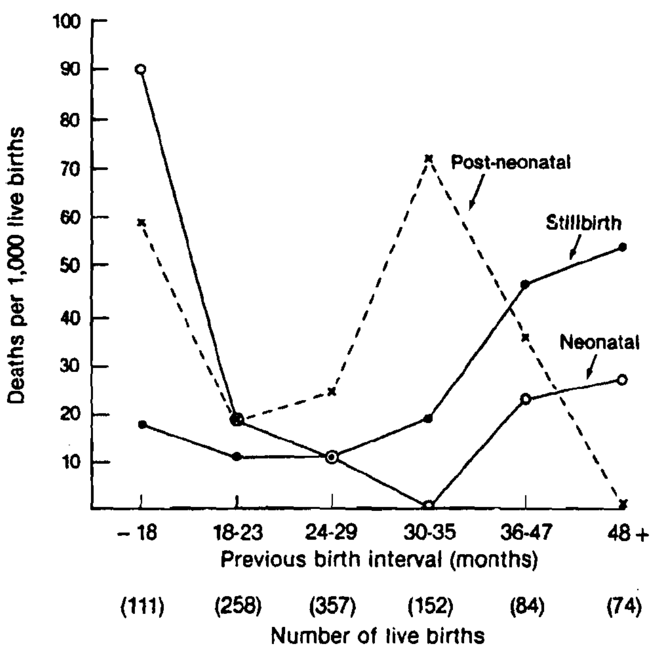
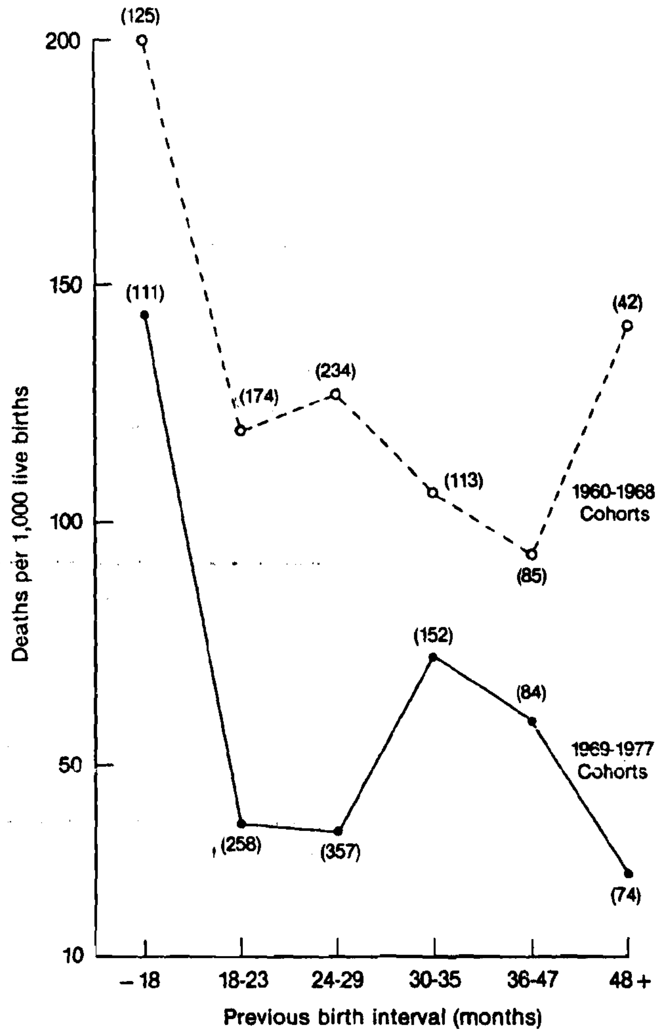


Figure XXVIII. Infant mortality rates for the 1960-1968 and 1969-1977 birth cohorts, by previous birth interval



NOTE: ( ) denotes number of live births.

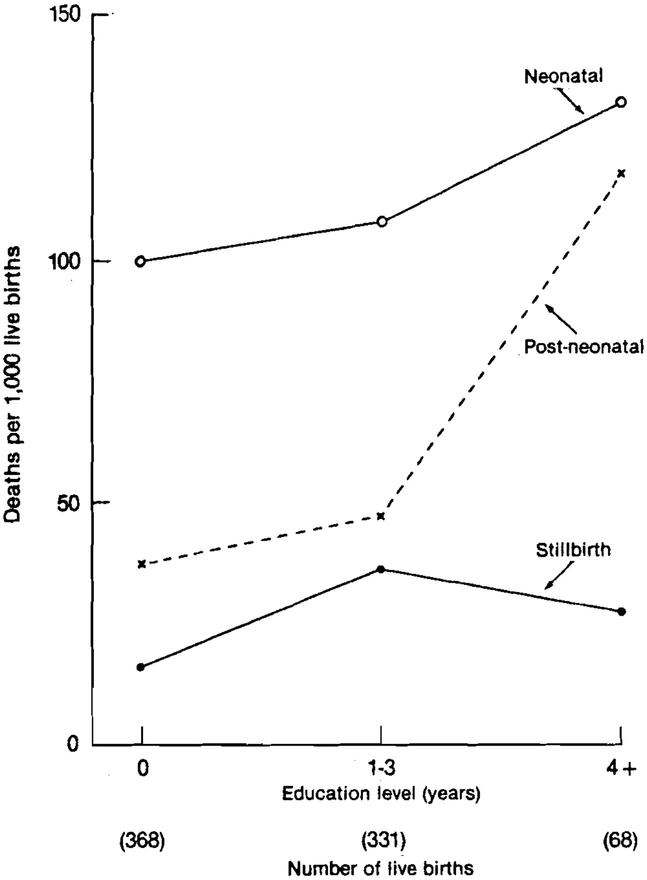
the greatest benefits from them. Another possibility, not to be overlooked, is that the mortality data collected from the pregnancy histories (i.e. the 1960-1968 cohorts) were more complete for the educated women, leading to an erroneous appearance that they experienced higher levels of infant and child mortality.

E. A SIMPLIFIED INTEGRATED MODEL OF HEALTH, NUTRITION AND FAMILY PLANNING SERVICES FOR RURAL AREAS

Based on the experiences presented in the previous sections, a generalized model for health intervention programmes within an integrated rural development plan was formulated.

The model of health, nutrition and family planning that is being proposed is based on the needs and resources of rural areas in developing countries. Implementation of this model requires two fundamental stages. The first stage includes an intensive diagnosis of specific local needs and available resources, the encour-

Figure XXIX. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by maternal education level, 1960-1968 birth cohorts



agement of community participation in the definition of needs, and the selection and training of local personnel. The second step is the actual operational implementation of the integrated system.

Diagnosis of local needs, resources and problems is carried out through a survey programme. These surveys serve both as a basis for local planning and as a measure of change in the future. The sample survey is designed to provide information on the most important characteristics of the community and the population, and its needs and resources. Data should be collected on: demographic characteristics (total population, age structure of the population, fertility and mortality rates), socio-economic characteristics (occupation, housing and educational level), health, nutrition and fertility needs (health status of the population to be obtained through a morbidity survey; nutritional status by anthropometric measurement and home dietary surveys; fertility by a simplified and improved knowledge-attitudes-and-practice survey (KAP)), other felt needs of the community, general characteristics of the community and its resources (existence of traditional medicine systems, human resources, health posts, water sources, wastage disposal systems, access roads, schools and communication systems).

In addition, through informal conversations and other qualitative or ethnographic data-gathering techniques, information about the organization of the community, decision-making and political processes and

Figure XXX. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by paternal education level, 1960-1968 birth cohorts

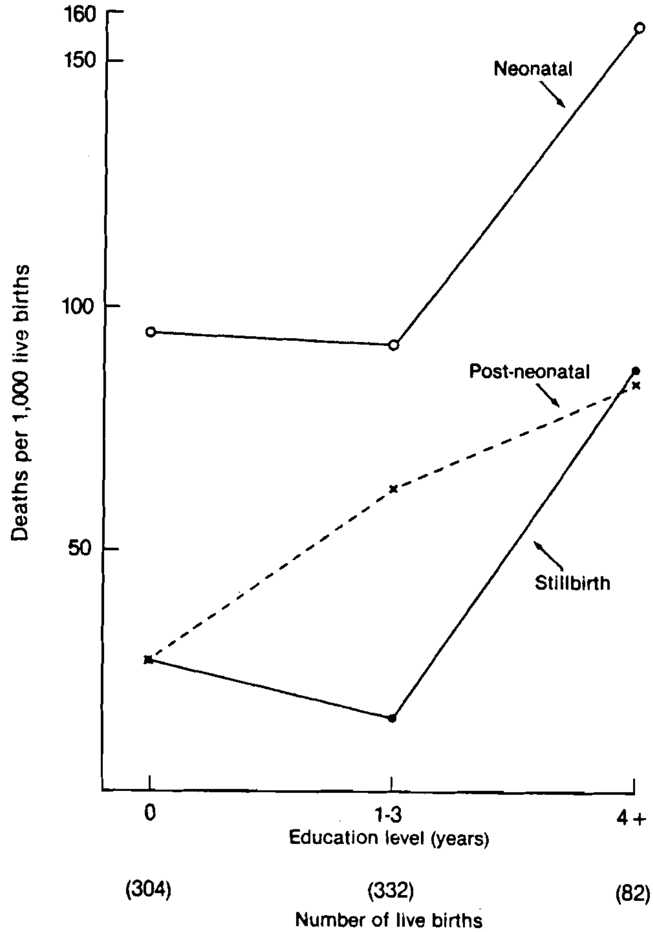


Figure XXXI. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by maternal education level, 1969-1977 birth cohorts

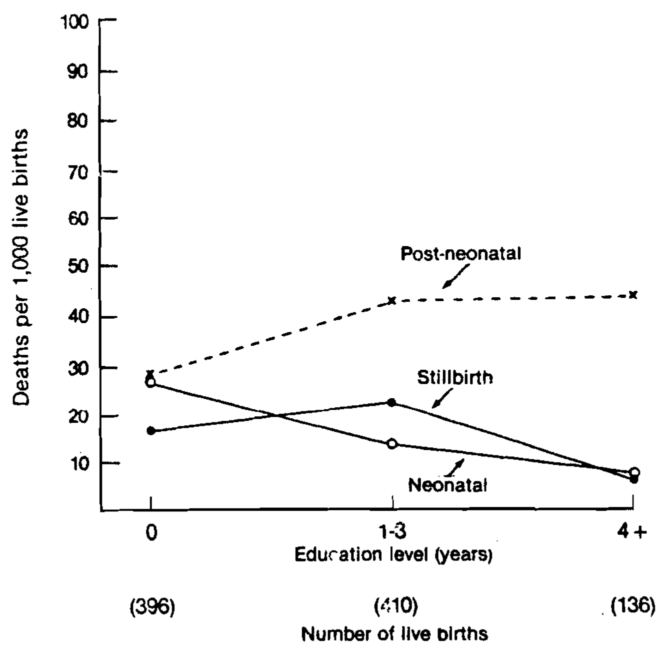


Figure XXXII. Stillbirth death ratio and neonatal and post-neonatal mortality rates, by paternal education level, 1969-1977 birth cohorts

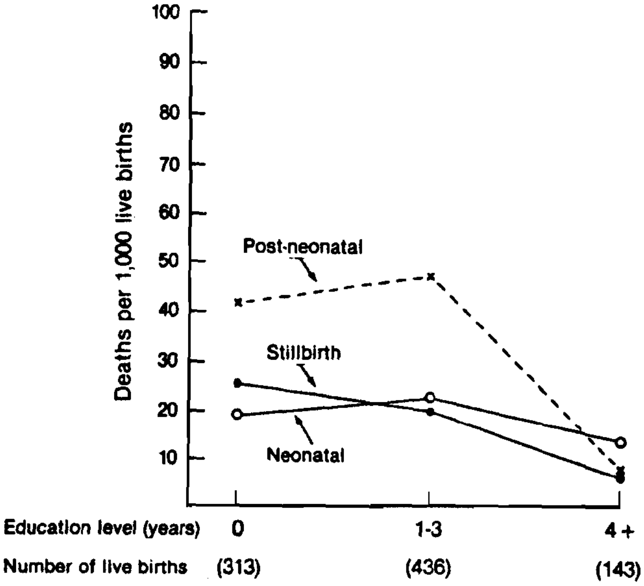
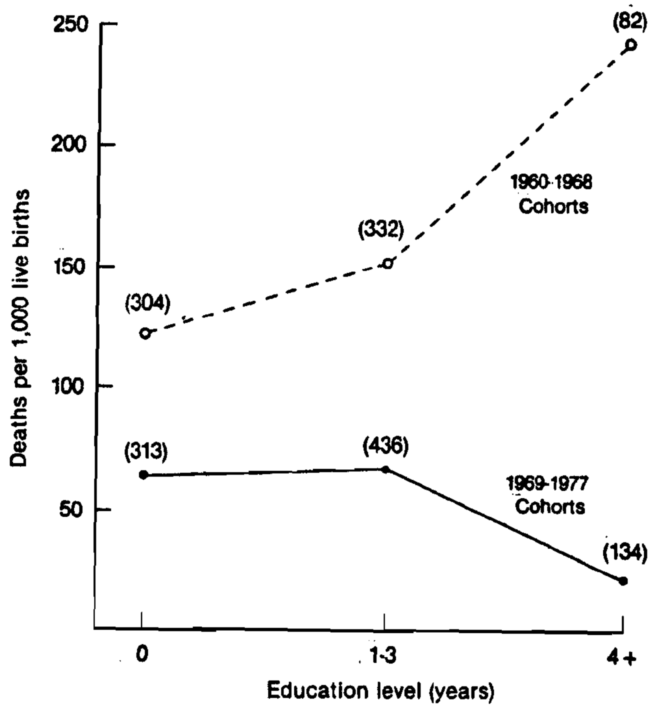


Figure XXXIII. Infant mortality rates for the 1960-1968 and 1969-1977 birth cohorts, by paternal education level

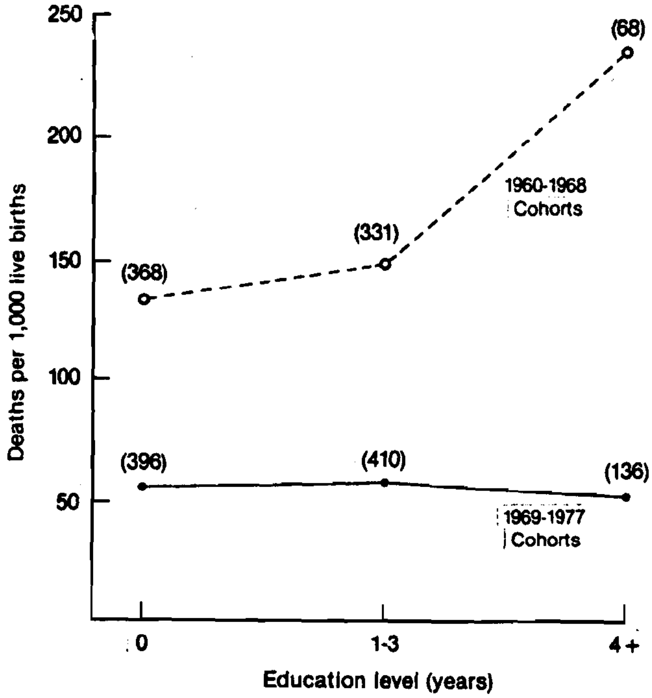


NOTE: ( ) denotes number of live births.

communication systems will be obtained. Background knowledge of the area will also be obtained by examination of other available sources of information such as government and ministry publications already available, past survey data and published literature.

Before conducting the sample survey, meetings with the local authorities, village leaders and other members of the community are necessary. The leaders of a com-

Figure XXXIV. Infant mortality rates for the 1960-1968 and 1969-1977 birth cohorts, by maternal education level



NOTE: ( ) denotes number of live births.

munity usually represent the most important political, religious and social groups but not necessarily the entire community. At these meetings the purpose of the survey and of the project should be explained and the organization of a pro-health committee is advised. This informed group ideally should participate in all future activities, including the survey, the discussion of the results, and the definition of priorities in accordance with needs, and they should support the operational implementation of the system. As part of their support, the committee has to select the persons who will be trained as health promoters.

In developing the present system, midwives, health promoters, auxiliary nurses, voluntary personnel and supervisors will be trained. Most of the training will be on-the-job.

General elements of the integrated model

Health sector priorities are to be assigned to the reduction of illness and deaths due to preventable and reducible diseases. Specifically, attention will be focused on communicable diseases, malnutrition, the health consequences of unregulated fertility, and prevention and health promotion. Moreover, emphasis is to be given to the most vulnerable age groups of the population, those younger than five years (especially those younger than two years) and women in reproductive ages (especially pregnant and lactating mothers).

Management of common diseases. Common diseases will be treated at the clinic level (health post at the village level) and at home. The auxiliary health personnel (promoters) will be responsible for providing medical care at home and at the clinic level. Following a simplified therapeutic guide, personnel will initially treat simple and common cases, especially diarrhoeal diseases and dehydration (which can be treated by oral rehydration) and mild respiratory infections. The promoters will also be taught to distinguish those illnesses which they can treat from those which should be referred to other levels of care. Based on their individual learning capabilities, the auxiliary personnel will be trained by the auxiliary nurse in the treatment of increasingly complex cases.

In order to perform their functions, the health personnel will conduct daily home visits. These individuals should spend at least 50 per cent of their time in the field. Each of the health promoters will be responsible for a sector of the community (of approximately 100 families each), and will visit a different portion, or sub-sector, daily. In addition, promoters will conduct daily visits to selected families in other sub-sectors, who are responsible for informing them about new cases of illness in that sub-sector. The promoter will also make follow-up visits to persons who have been treated for illness. The supervisor of the health promoter is the auxiliary nurse. She will review the information collected by the health promoter, will treat the cases referred to her and will visit a sample of houses previously visited by the promoter to control for quality of health care. This supervising system will be a constant feature of the model.

Care during pregnancy, delivery and post-partum. The personnel responsible for providing health care during pregnancy, delivery and post-partum will be the auxiliary nurse at the clinic level and the health promoters and midwives at home. Where traditional midwives exist, these should be integrated into the model. This model should not be co-operative, not be competitive, with the traditional medical system.

The type of care proposed is based on early detection of pregnancy, the determination of women at high risk and the education of women of reproductive ages. The early detection of pregnancy and the categorization of individuals and groups according to levels of risk will significantly improve the coverage and efficiency of the programme. When pregnancy is suspected, by either the health promoter or the midwife, the woman is referred to the health post, where the auxiliary nurse will confirm (or not confirm) the pregnancy.

The auxiliary will then categorize a positive case as a low-, middle- or high-risk pregnant woman. In addition, the information collected will permit the auxiliary nurse to suggest where the delivery should take place (i.e. home or hospital).

In order to categorize the case, she will utilize a set of risk factors that will be taught to all auxiliary nurses. These high-risk factors are:

(*a*) By history: mothers under 16 and over 35 years of age; elderly primiparae; unmarried women; complicated reproductive history (abortions, stillbirths, prematures, abnormals; history of long, obstructed labours); high parity; closely spaced pregnancies; history of high infant and child mortality within the family and some socio-economic characteristics of the family;

(*b*) By physical examination: anthropometric measurement of the mother (low height, small head and/or arm circumference); pelvic deformities; abnormal relation of uterine height and gestational age; undernutrition; hypertension; edema; albuminuria; vomiting; anaemia (by examination of the conjunctiva); diabetes etc.

High-risk cases will be carefully monitored at the health post. Middle- and low-risk cases will be followed up by the health promoter and midwife, who will be trained in the detection of complications during pregnancy, i.e., vomiting, persisting headache, edema, convulsions, hemorrhage. These cases will be referred to the health post or for higher levels of care.

In addition, a second examination of initially low-risk cases will be conducted by the auxiliary nurse during the third trimester of pregnancy to screen for high risk during delivery.

The midwives will be responsible for assisting in the majority of deliveries at home. They will be trained in the detection of complications during delivery and post-partum (i.e., premature rupture of membranes, prolonged labour, abnormal presentations, retention of the placenta, infections) that should be referred to the clinic.

Infant and child care. Infant and child care will be provided by the auxiliary nurse at the clinic level and by the health promoter at home. As in the case of maternal care, infant and child care will be strongly based on the utilization of the high-risk approach. In addition, a programme of immunization and health education is contemplated. In order to identify children at risk, the promoter will be trained in the use of simple indicators which are sufficiently valid and reliable to establish which children require greater attention, from the point of view of health and illness as well as nutrition. In the course of their weekly visits to houses, and based on anthropometric measurements (arm circumference, height and weight where possible) and on information of morbidity of the child during the last week, the health promoters will treat or refer the cases to the clinic. The promoter will be trained to recognize the higher risk of dying of an infant with diarrhoea, with blood and mucus in his stools for more than three days, with vomiting, fever and multiple depositions as compared with that of a simple diarrhoea.

Similarly, he or she will be able to identify and treat or refer to the clinic acute cases of malnutrition. At the clinic level, the high-risk cases will be treated by the auxiliary nurse and the health promoter responsible for the case with appropriate foods and medicines. In addition, the nature of the disease and its treatment will be explained to the mother in order to have her participate in follow-up maintenance of treatment and learn from the experience.

Family planning. Provision of family planning services will include education, treatment of infertility and motivation for the use of contraceptives to limit family size and to space children (particularly in high-risk cases), provision of contraceptive services and follow-up of users. The contraceptive methods that will be available include promotion of breast-feeding, instruction in the rhythm method, condoms, vaginal foam tablets, diaphragm and spermicidal creams, oral contraceptives, intra-uterine devices, male and female sterilization. Advantages and disadvantages of the various methods will be discussed with potential users, and no pressure tactics or incentives will be used. All these family-planning methods will be provided at the clinic level and at home. In order to supplement home contacts, group meetings of both men and women will be organized to discuss various aspects of family planning and welfare.

Prevention. Leavell and Clark's (1965) description of the application of preventive measures distinguished three levels: primary, secondary and tertiary prevention. Health promotion and specific protection constitute the phases of primary prevention; secondary prevention comprises the early diagnosis, treatments and disability limitation, while rehabilitation is the focus of tertiary prevention. Primary prevention is the focus of the programme and it will be achieved in several ways: personal health services, environmental control measures and promotion.

Personal health services include two main activities: the immunization against communicable diseases and the identification of high-risk cases. It is now widely recognized that children need to be immunized against tuberculosis, diphtheria, pertussis, tetanus, measles and poliomyelitis, and mothers during pregnancy need immunization against tetanus to avoid tetanus neonatorum. The effectiveness of these immunizations can hardly be questioned. However, it is equally clear that in rural areas of developing countries relatively little use has been made of immunizing agents or of the cold chain for the preservation of the vaccines. In this programme, high coverage and continuity can be obtained through the weekly home visit of the health promoter.

The second activity under consideration is the selection of high-risk cases. Some of the indicators have been previously described. Among the measurements that we have developed and used as risk factors are anthropometric measurements of the mother and a housing scale as a measure of the socio-economic condition of the family.

It has been found that mothers of low-birth-weight babies are typically small in stature and head circumference and that their houses tend to be of poor quality. A validation of the capacity of these factors to predict low-birth-weight babies through a food supplementation intervention was done. It was found that the probability of high-risk mothers having a low-birth-weight baby is reduced by caloric supplementation during pregnancy to values similar to those observed in the low-risk group of mothers. Furthermore, the probability of a low-risk mother having a low-birth-weight baby was not affected by food supplementation during pregnancy (Delgado, Lechtig and others, 1976 and 1978). Clearly, these indicators can predict risk, and the level of risk can be affected by simple interventions. These indicators do not require expensive resources in terms of personnel and equipment, can be reliably assessed at the field level and are easily interpreted.

Environmental control measures constitute another way in which primary prevention will be achieved in our programme. The World Health Organization (WHO) considers that the provision of a safe and convenient water supply is the most important simple step that can be undertaken to improve the health of children in rural areas. Safe water for drinking and for better personal and household hygiene can significantly reduce the incidence of gastro-intestinal diseases. In addition to the provision of water, there is need of a major educational effort for promoting proper water utilization. Also planned is community education to ensure proper disposal of human and garbage waste. Latrines and garbage pits constitute cheap and practical ways of solving the problem. The use of safe water, household latrines and community garbage pits constitute important elements among those basic services necessary for the improvement of the standard of living.

The success of environmental control programmes requires the community to play an active role. Community development demands that the population be kept well informed, participate in the decision-making process and contribute human and material resources. Community participation in all preventive and protective measures is viewed as a key factor to guarantee that the population will accept and use the services.

Health promotion, the third important method of primary prevention, has recently received a good deal of attention from health professionals. Health promotion is aimed at informing, influencing and assisting both individuals and groups to accept more responsibility and be more active in matters affecting health (Lalonde, 1974). Based on this definition, Lauzon (1977) stated that health promotion means much more than the concept of health education. Most health education in the past has relied on knowledge transfer to achieve change in behaviour, and has been unsuccessful.

Lauzon proposed a health promotion paradigm that attempts to consolidate past and present health-related influence strategies into a taxonomy of health promotion activities. His presentation will be followed as a guideline for describing the activities to be developed in our simplified model. In his epidemiological approach to health promotion, Lauzon distinguishes three types of health promotion activities: host-oriented, agent-oriented and environment-oriented activities.

Our programme will focus on the host-oriented health promotion activities, which aim to make the host more resistant by modifying factors that influence health and illness. These activities include instruction, education and behaviour modification, persuasion, proselytizing, screening and counselling.

(*a*) Instruction will be given to the health personnel, pro-health committee members and voluntary personnel with respect to health-risk factors, in order to change harmful habits and to stimulate the development of practices which safeguard health.

(*b*) Education will be given to the entire community and will be aimed at achieving changes in behaviour. This will be done by the implementation of educational programmes that follow the principles of social learning theory. The theory implies that modification of behaviour will be obtained through stimulation, participant modelling and reinforcement.

Programmes based on this model are increasing in the health education field. The focus of our educational programmes will be on environmental sanitation and hygiene, infectious diseases and nutritional problems. Experiences in the area of health education are somewhat limited, though some success has been obtained in terms of knowledge transfer through the use of educational films followed by a clear discussion of the message by a local health promoter or a member of the pro-health committee in pilot project. Clearly, education should be given in native languages and material should be appropriate for rural population.

(*c*) Persuasion refers to the utilization of messages intended to encourage target behaviours. In this programme, persuasion will be an important component of the promotional effort to organize sub-groups of the population, such as religious groups, social groups, local authorities and school students.

(*d*) Proselytizing is expected to occur as a result of the instruction and involvement of the health promoters, pro-health committee members, voluntary groups and health team and their interaction with the community.

(*e*) Among the host-oriented health promotion activities, the identification of groups of population at different levels of risk through screening has had the greatest success. As explained previously, the risk approach takes into consideration that within apparently homogeneous populations, there are groups of individuals who may be at higher risk for some factors than others. The high-risk populations, e.g. mothers with malnourished children, usually are more attentive and receptive to information and have a higher motivation to change behaviour than the healthy groups. In this programme, the high-risk population will be identified in order to direct more appropriate messages to them.

(*f*) Finally, counselling, defined as the personal guidance of any individual, will be done at the clinic level and at home, in the context of the periodic visit of patients to the clinic.

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