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"ESTIMATION OF MORTALITY LEVELS AND THE IMPACT OF MAJOR CAUSES OF DEATH: A CASE STUDY FOR NAIROBI, NYERI AND BUNGOMA DISTRICTS". //

By

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DECLARATION

This project is my original work and has not been presented for a Degree in any other University

5/4/2003

(Christoper Ndayara Omolo)

The project has been submitted for examination with approval as University a Supervisor.

7/11/2003

(Dr. Boniface K'Oyugi)

Dedication

This project is dedicated to my wife Lucy, Son William and Daughter Priscilla who encouraged me and remained patient and understanding for the period of my studies.

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ABSTRACT

Demographic surveys and population censuses only give the number of deaths without indicating the causes and this limits the usefulness of the data in designing health policies and programmes. Under the civil registration system, not all events are registered in some of the districts in the country. It has therefore become necessary to evaluate death registration data and estimate mortality levels based on the adjusted data.

This study set out to estimate completeness of death registration; estimate mortality levels; generate life tables and compare the results with the census results for Nairobi, Nyeri and Bungoma districts. The study also set out to estimate the effects of hypothetically eliminating single causes of death on life expectancy. The study applies the Brass Growth Balance method and the Bennett-Horiuchi method. The data used in the study are the 1989 and 1999 population census data and the death registration data captured for the year 1999.

The Brass Growth Balance method estimates completeness of death registration to be 55, 127 and 105 percent among males and 138, 94 and 76 percent among females in Nairobi, Nyeri and Bungoma respectively. The Bennett-Horiuchi method estimates death registration completeness as 61, 56 and 122 percent among males and 130, 42 and 95 percent among females in Nairobi, Nyeri and Bungoma respectively. The degree of completeness from the two methods are comparable for the Nairobi and Bungoma data but markedly different in respect of the Nyeri data. Both methods generates the completeness of death registration that are too low for males in Nairobi whereas the

Bennett-Horiuchi method grossly underestimates the completeness for both sexes in Nyeri district. Overall, the Brass Growth Balance method underestimates the life expectancies whereas the Bennett-Horiuchi method overestimates the life expectancies at most ages as compared to the census results. Since different estimation procedures are sensitive to a variety of possible sources of distortions on data in different ways, it is important that different methodologies are applied in estimation procedures to serve as consistency checks on the results obtained.

For the Kenya to discard its reliance on indirect methods of estimation and rely more on the direct methods of estimation, the coverage and quality of the data generated from the censuses and registration systems must be improved. This therefore calls for a holistic approach to addressing the issues that affect quality of data in this country. Apart from allocating more resources to the relevant departments, the populations' levels of education and standards of living must be improved.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction:

The earliest data on mortality in Kenya were estimated crudely from data that were often collected for other than demographic purposes. Early direct attempts to measure mortality were also inadequate and probably understated mortality levels (Mott, 1979). The first census was conducted in Kenya in 1948 and the second conducted in 1962. Since then, the Kenya Government has been conducting censuses on a decennial basis and the last census was undertaken in 1999. These censuses have been primarily concerned with fertility and mortality but data have also been collected on aspects of migration, and other socio-economic characteristics of the population.

Demographic surveys have also been carried out in the country on a sample basis. These surveys include KFS (1977/78) and Kenya demographic and Health Surveys of 1989, 1993 and 1998. These surveys were designed to collect information on population; health and nutrition, measure differences across the country in fertility and use of family planning; monitor changes in population, health and nutrition and maternal mortality levels.

The data available for mortality studies have therefore been mainly from censuses and sample surveys. Mortality estimates in Kenya are mainly from responses from simple questions in these studies where indirect methods of estimation have been applied extensively. However, doubts have been raised about the performance of these methods because some of the assumptions they are based on are not realistic under changing fertility and mortality conditions in the Kenyan population. It has therefore become necessary to evaluate the quality of data from the registration system so that the estimates may be compared with the results from the traditional sources.

The changes in the patterns of mortality and causes of death in developing countries has made it imperative that different sources of data in estimating mortality levels be used. Indeed, it has also become important to estimate cause-specific mortality levels to understand the impact of the major causes of death on mortality in light of the new emerging and re-emerging diseases such as HIV/AIDS.

Levels of mortality relate to cause of death through socio-economic, socio-cultural and health factors. The focus of the epidemiological transition theory, according to Omran, is on ' the complex change in patterns of health and disease and on the interaction between these patterns and their demographic, economic, and sociological determinants and consequences' (Omran, 1971). Sleeping sickness, malaria, plague and malnutrition plagued the African population in the early 1900's (Kuczynski, 1949). Some of these diseases have been eliminated through public health programmes and provision of health services.

1.2 Statement of the problem

Measurement of levels of mortality in developing Countries has been of major interest to policy makers, particularly in the Health sector. However, demographic surveys and censuses mainly give the number of deaths without indicating the causes of death.

Consequently, however accurate these mortality data results from census and surveys may be, without knowledge of the causes of death, they may not serve any useful purposes in connection with the Government's efforts to improve the health status of the population. Data gathered through the continuous registration of deaths is meant to address the data gaps on the cause of death. These types of data will be able to provide descriptive data measuring the relative magnitude of different health problems at different regional levels so as to establish health priorities and also to identify differentials, which might define risk factors or subgroups at risk, so as to devise intervention strategies. Since deaths are relatively rare events, particularly among adults in the age range 15 to 60 years relative to deaths in childhood or old age, it normally requires large samples in demographic surveys for the estimation of vital rates such as maternal mortality levels (W.H.O, 2000).

Whereas maternity histories given by mothers generally provide satisfactory estimates of child mortality, event histories that can provide complete and timely estimates of adult mortality are not available. It is generally difficult to identify the right informant to provide information on adult deaths, which leads to undercounting and multiple reporting. Indeed, very few demographic surveys attempt to obtain data on 'cause of death' because of the difficulties with retrospective verbal autopsy and the limitations on interview time and questionnaire complexity.

Though Kenya has a registration system, not all the events are registered in a number of the districts. The death rate implied by the reported deaths from the registration system thus underestimates the true death rate for the affected districts. The under-registration also affects the estimation of age-specific and cause-specific death rates. The absence of comprehensive data on vital events is therefore an impediment towards efforts to improve knowledge on levels, structure, patterns and differential and trends in mortality in the country. The Kenya Demographic and health surveys that are conducted after every five years can only generalize its findings up to the Provincial level and this affects the availability of relevant information at the district for proper planning, given that the Government of Kenya has decentralized the planning responsibilities to the districts.

Mortality estimates in Kenya, both at the national and district levels are based mainly on indirect methods of estimation, some of which may not be adaptable to the local population. The indirect techniques rely on age-specific mortality schedules produced by Brass et al (1973) (the Brass relational system); Coale and Demeny (1966) (the Coale and Demeny model life-table system) and the United Nations (1982) (the UN life-table system). The above life table systems are 30-50 years old and may therefore not be suited for the Kenyan population because of the recent developments on the demographic scene. Furthermore, the Coale and Demeny system and the United Nations model life tables were generated with minimal data inputs from Africa whereas the Brass relational system relied on data from only West Africa. The problem has been aggravated by the fact that the information collected from civil registration system in Kenya is not analyzed and thus the monitoring of mortality levels and trends is incomplete. This study therefore tries to estimate the general mortality levels and the impact of the major causes of death for Nairobi, Nyeri and Bungoma. These three districts have been targeted for this study because it is only in them that the required data was captured.

1.3 Research questions:

1. To what extent does the mortality estimates derived from methods using civil registration data compare to the mortality levels derived using data on child survival and orphanhood?
2. What is the impact of the major causes of death on mortality in the three study districts?
3. What are the levels of death registration in each of the study districts?

1.4 Objectives of the study:

The general objective of the study is to estimate mortality levels and the impact of major causes of death on mortality for the study districts.

The specific objectives of this study are:

i) estimate the level of completeness of death registration for each of the study districts.

ii) generate mortality life tables for each of the study districts from methods using death registration data and comparing with those derived from child survival and orphanhood data.

iii) assess the effect of specific causes of death on mortality for the major causes/diseases.

1.5 Justification of the Study:

Mortality is associated with social, economic, cultural and health care factors. It provides information for health decision making to analyze the level and risks of death. Since different regions in the country vary in geography, economic, cultural and health care, the study of mortality at the district level has a lot of significance. This study is therefore important since the results will be a key input towards the control of morbidity and thus in determining the necessary action to improve the health status of the population in the respective districts. Uniformities and differences observed in the three districts will serve as an important indicator since the distribution of health related factors such as social, economic and physical will be revealed. Since this study analyzes mortality and causes of death at the district level, it is envisaged to:

i) provide information on the risks of dying among the different age groups and sexes and the major causes of death for each of the districts in the study.

ii) assist in providing the necessary information for making decisions on priorities for health action for each of the districts in the study.

iii) serve as an indicator of programme performance on the programmes already in progress and thus reflect on achievements in the health sector in each of the districts in the study.

1.6 Scope and limitations of the study:

This study focuses on three regions of Kenya: (Nairobi, Nyeri in Central Province and Bungoma in Western Province). Because of the limited coverage, it would therefore not be possible to generalize the results at the national level and neither is it possible to disaggregate the data to the Division, Location or Sub-location levels. It would also not be possible to have trend data and therefore evaluate the performance of the registration system over the years since the data only covers the year 1999.

The study will not examine the impact of social, economic, cultural and health care factors on the levels and structure of the mortality in the three districts. The study will thus be restricted to the completeness of death registration and the cause-elimination effects on mortality for the major diseases in each of the three districts.

The other major limitation will be the underlying assumptions of the models being applied in the study. The assumptions that the population is closed may not be realistic, particularly for a wholly urban district like Nairobi. The assumption that population is stable may not be realistic because of the recent changes in fertility and mortality.

CHAPTER 2

LITERATURE REVIEW AND ANALYTICAL MODELS

2.1 Introduction

In this section, we review literature on studies that have been conducted on mortality and causes of death with particular reference to developing countries and those conducted in Kenya. The literature review thus provides a basis for this study.

2.2 Studies in the rest of the world:

Several studies have been conducted using different methodologies whose results have in some instances not agreed. This may be due to fertility and mortality changes realized in most populations in the world. Fertility and mortality have been changing in most developing countries since the 1950s and the economic development realized in some of these countries has also had an impact on mortality levels and patterns.

Kenneth Monton (1982) analyzed the temporal trends in the United States and multiple causes of death on mortality data for the period 1968 to 1977 indicated by two types of cause-specific mortality data. The first type of data was the 'underlying cause' of death data and the second was the 'multiple cause data', which contained a listing of all medical conditions recorded on the death certificate. A comparison of trends in the two types of data showed mortality declines over the study period which he attributed to a reduction in the mortality of circulatory diseases over much of the age range and the fact that the multiple cause data contain considerably more information than the underlying cause data on the role of circulatory diseases and many other chronic diseases, in causing death.

The reductions in circulatory mortality risks contrasted sharply with previous mortality reductions due primarily to declines in the mortality risks of infectious diseases. He observed that the multiple cause data were of particular importance, since they contained additional information about the occurrence of chronic and degenerative disease as factors associated with death even when the disease is not itself the underlying cause of death.

According to Wu Tiejian and Wang Junle (1998), in a study on the factors influencing infant death in rural areas in China found that, the main causes of infant death were pneumonia (23.53%), congenital deformities (22.55%), premature (10.78%), newborn sclerodema (9.80%) and suffocation (7.84%). The study also found that there had been a shift in the main causes of infant death since 1949.

Hansluwka and Ruzicka (1980) looked at the health spectrum in South and East Asia and found that it was essential to assess mortality patterns and trends from a public health point of view and to view them against the background of the health situation in a given country as manifested in the disease pattern, in health policy, and in the organization of the health services. They also found out that there was relatively little change over a period of 20 years in terms of the major causes of death in South and East Asia. Malnutrition and infective and parasitic diseases dominated the picture, with malaria heading the list followed by tuberculosis and leprosy. Acute diarrhael diseases including cholera had retained their importance.

Flieger (1980) in his study of the levels, trends and differentials in mortality found that of the ten leading causes of death; five were exclusively or largely infectious in nature (pneumonia, tuberculosis, bronchitis, gastro-enteritis and measles) and together with malnutrition, found predominantly in subsistence or below-subsistence living conditions. The results showed that deaths due to infectious diseases and malnutrition showed signs of decline between 1966 and 1976 and deaths caused by degenerative diseases were on the rise.

Ling (1980) in his study of the mortality of Chinese population found that in the period 1954-1959, diseases of the respiratory system, pulmonary tuberculosis, diseases of the digestive system and acute infectious diseases were the main causes of death accounting for 34.4 percent to 39.6 percent of all deaths in urban areas. The percentages dropped to between 17.3 percent and 21.8 percent in 1974-1978 respectively. In 1954-1959, heart diseases, cerebrovascular diseases and malignant neoplasm were the second most frequent causes of death accounting for 15.3 percent to 19.7 percent of all deaths. But in 1974-1978, these diseases were the leading causes of death and accounted for 58.0 percent to 63.8 percent of all deaths. Diseases of the respiratory system ranked first among the causes of death from 1954 to 1963. But by 1974-1978, they had dropped to fourth place. The cause-specific mortality attributed to these diseases was reduced by about 50 percent to between 51.1 and 55.5 per 100,000 population. Primary tuberculosis ranked second or third among the causes of death between 1954 and 1958. But in 1974-

1978, it had dropped to sixth or seventh place. The cause-specific mortality was also reduced by about 71 percent to between 15.7 and 21.3 per 100,000 population. In 1974 to 1978, heart disease, malignant neoplasm and cerebrovascular diseases occupied the first three ranks among the causes of death in rural areas. The proportion of deaths attributed to these groups of causes taken together was between 47.7 percent and 54.3 percent of total deaths. The cause-specific mortality of heart diseases and malignant neoplasm was similar to that of the urban population, but in the case of cerebrovascular diseases the rate was lower in urban areas. The mortality due to diseases of the digestive system and acute infectious diseases was higher in the rural areas than in the urban areas for the same period.

Concepcion (1980) while analyzing the factors in the decline of mortality in the Philippines, 1950-1975, found that diseases such as pneumonia, influenza, bronchitis, dysentery, gastro-enteritis, and nutritional deficiency which are associated with development induced environmental changes had manifested major declines since 1950. The death rates for malaria, measles and tuberculosis had likewise fallen. Between 1950 and 1960, the death rates due to all the aforementioned causes of death declined by 39 percent. Between 1960 and 1970, mortality from these two sets of causes declined by 22 percent.

In his study on the 'effects of adverse socio-economic factors and disease on the nutritional status of children under five in Zimbabwe', Madzingira (1994) found out that the nutritional status of a child is determined by a variety of interrelated factors that are biological, social, cultural and economic in nature. He observed that even though variables impact on nutritional status in different ways, these variables are interrelated. The roots of malnutrition extend beyond the reach and influence of health and nutrition remedies into the environment, tradition and economy of the people.

In the Sumve survey on adult and childhood mortality in Tanzania in 1995, it was found that for 10 percent of the males deaths and 5 percent of the females deaths, no useful information was provided by the respondents that would allow the cause-of-death classification. The information on females was more completely reported because some maternal deaths in particular were more readily defined and the respondents were female and therefore may have been more familiar with the circumstances surrounding their sisters' deaths than those of their brothers' deaths. It was also found that nearly 33 percent of all female deaths were maternity-related. Of the remaining female deaths, 6 percent were AIDS-related, 9 percent were reported as due to tuberculosis, 12 percent to malaria/fever, 14 percent to "other" (named) specific infectious diseases, 5 percent to traumatic events including accidents and murder, 25 percent to reported "pain" (mainly "abdominal pain"), and 22 percent to "other" causes that included unspecified signs such as "swelling" and "bleeding". Two percent of non-maternal female deaths were reported to have been caused by "bewitchment".

The study found that the distribution of male deaths by reported "cause" was similar to the non-maternal mortality female-cause-of-death distribution, except that deaths associated with various "pains" and malaria/fever were less commonly reported and related to traumatic events, bewitchment, and other unspecified causes were more commonly cited amongst the male deaths. The most important finding in the study was that high proportion of all female deaths (33 percent) were related to maternity-related causes.

2.3 Studies done in Kenya

Using the Brass Growth Balance Technique, Koyugi (1981) estimated the degree of completeness of death registration in Siaya District and found that the 1977 vital registration data on deaths for females and males were 47 and 112 per cent respectively. The study also found out that air-borne diseases, water, food and faeces borne diseases and insect-borne diseases were the most dominant in the district. The major causes of death were measles, respiratory diseases, cerebrovascular diseases, diarrheal diseases, tuberculosis, heart diseases and meningitis all which accounted for 70 per cent of the total registered deaths in the district in 1977. One interesting finding from the study was the dominance of heart diseases, which are associated with developed countries, which normally have an aged population.

In constructing Kenya's life table from incomplete death registration data, Makoteku (1985) applied the age specific growth rates method, which is applicable to any closed population and essentially derives from extensions to stable population theory. He found that only 22.2 per cent of all male deaths and 12.7 per cent of all female deaths were registered. The data used was the deaths registered in 1979 and the rates were calculated relative to the 1979 population census results.

Kizito (1985) when estimating adult mortality differentials in Kenya using life table technique found that the death registration in Kenya at the national and district levels were incomplete. The quality of most of the death registration data in most districts was found to be better for males than for females.

For males the results were that, Siaya district had a relatively better death registration process than the other districts whereas Turkana, Elgeyo Marakwet and Samburu had a relatively poor death registration process. For females, the relatively better registration data was found in Nairobi, Mombasa and Uasin Gishu and the least relatively reliable one was found in Elgeyo Marakwet, Turkana and Marsabit.

The life tables he constructed gave higher life expectancy estimates for males than that for females in some of the districts at ages 0-45. At age 55, the life expectancy estimates for females were lower than those of males in several districts when the age-specific growth rate technique was used whereas they were mostly higher for males than females when the Preston-Census method was applied. The results from the two methods were generally mixed.

Nyokangi (1984), in his study on mortality estimations in Kenya with special reference to causes of death found that completeness of death registration in Kenya was poor. He estimated the completeness to be 22.2 per cent for males and 12.7 per cent for females. He estimated life expectancies from two indirect methods of constructing life tables, which revealed that below age 35 years for males and age 45 years for females, life expectancy estimates due to the Bennett-Horiuchi method were systematically relatively higher than corresponding values due to the Preston –Census method. He also observed that at all ages, the life expectancy estimates obtained by the Bennett-Horiuchi method using the 1979 registered deaths agreed relatively better to the corresponding life expectancy values in the National 'Model' life tables-1979, than the corresponding life expectancy estimates due to the Preston-based method, using the 1969 and 1979 population censuses.

Using multiple-decrement approaches, the cause of death analysis showed that for all the groups of causes of death studied except for the accidents, the risk of dying was always high at the beginning and at the end of the life span, lowest at puberty, and low with an upward slope during the long period of adulthood. For accident, he found the risk of dying high during active years of life and higher among males than females. Accidents were found to be the leading cause of death for males between ages 15 and 45 years. Among females it was the third leading cause within the same age interval.

The study also found that when a particular group of causes is hypothetically eliminated it revealed the existence of age, sex and cause of death differentials in mortality. Thus the major causes of death in Kenya were infective and parasitic, respiratory and circulatory system diseases.

In its report for the period 1996 to 1999, the Health Management Information Systems of the Ministry of Health, it was reported that the leading causes of morbidity in Kenya during 1999 was malaria which accounted for 32 percent of the total new cases reported. The diseases of the respiratory system (including pneumonia), skin diseases, diarrhoeal diseases and intestinal worms were the other major diseases in that order.

The report also observed that the single most common condition among the reported causes of hospitalization was malaria accounting for nearly one-fifth of the total. The second condition was related to child delivery (14.1 percent) while pneumonia represented 9 percent of the total conditions. Diarrhoea, injuries and anaemia were next accounting for 4.7 percent, 4.6 percent and 4.1 percent respectively.

In 1999, malaria was the leading cause of death responsible for 13 percent of all deaths reported in Government hospitals followed by pneumonia. HIV/AIDS was an important cause of death accounting for 7 percent of all deaths reported. However, the deaths from HIV/AIDS may have been under-reported since many of the deaths related to AIDS occur at home where reporting is poor.

For children aged 1 to 4 years, the dominant cause of hospitalization was malaria, pneumonia and anaemia. The three conditions account for a half of all cases reported among children in this age group. The group of infective and parasitic diseases was responsible for about 31.2 percent of all reported causes of hospitalization; pregnancy, childbirth and puerperium (13.8 percent); diseases of the respiratory system (12.1 percent); injury, poisoning and other consequences of external causes (7.3 percent). The four categories constitute nearly 64 percent of all causes of hospitalization. Dehydration, essentially a childhood condition, represented 3 percent of total deaths.

Muller et al., (1984) in their study in Machakos district found that the probability of dying was highest within 24 hours after birth and declined gradually until the fourth month among infants. The death rates were somewhat elevated between six and nine months after birth. Male mortality was considerably higher than that of females in the first week after birth; in later months, the differences were small. The study estimated the overall infant mortality at 49.7 per 1000 births.

The study found that mortality declined sharply after the first year of life. In the later adulthood (age 45-64) rates increased again, reaching their maximum (29 to 47 per 1000) in the ages 65 years and later. Mortality in Machakos based on infant and child data, did not vary significantly by season.

The study found that the leading cause of death in Machakos was respiratory illness, particularly pneumonia, which accounted for 15.8 percent of all deaths. Second in rank was found to be congenital anomalies and perinatal conditions, which accounted for 12.8 percent of all deaths. Intestinal infectious diseases (particularly diarrhea) and measles ranked third and fourth, respectively with 10.8 and 8.1 percent of all deaths. Malaria caused only 3.1 percent of all total deaths, probably because of the area's high altitude.

The study found out that, congenital anomalies and perinatal conditions (12.8 percent), respiratory diseases and intestinal infectious diseases (9.7 percent each) and measles (7.1 percent) were the leading causes of death among infants and children below five years of age. Diseases of the circulatory system (7.2 percent), tuberculosis (6.2 percent), diseases of the respiratory system (7.0 percent), external causes of injury and poisoning (5.6 percent) were the important causes of death for persons more than five years old. Causes related to neoplasms and diseases of the circulatory and digestive systems were only reported for persons above five years of age. Among infants, pneumonia and influenza

(15.7 percent), and intestinal infectious diseases, especially diarrhea (15.4 percent) were the major killers. Among children aged one to four years of age, measles and nutritional deficiencies were the leading causes of death, accounting for 9.8 and 5.0 percent of all deaths.

About 62 percent of all deaths occurred at home and 38 percent in hospital. Deaths due to diseases of the circulatory system and malaria occurred more frequently at home than elsewhere, and those due to congenital anomalies and perinatal problems, measles, and neoplasm took place more in hospital.

The cause-of-death structure in Machakos resembled that in a number of developing countries. Deaths due to infectious diseases (35.6 percent) followed by diseases of the respiratory system (15.8 percent), congenital anomalies and perinatal conditions (12.8 percent), diseases of the circulatory system (7.2 percent) and external causes (6.2 percent).

2.4 Summary of Literature Review

It is evident from the literature review that social, economic, cultural, climatic, health care and demographic factors influence mortality levels and patterns. It is also clear that there are marked differences in the major causes of death between the developed and the developing countries. In classifying major causes of death in most countries, it is apparent that preference is given to the underlying causes and therefore most of the studies don't establish the links between all the medical conditions on the death certificates. This means that only one medical condition is analyzed in most of the studies which may not reveal the true picture of disease profile in the population under study.

The differences in major causes of death between developed and developing countries reveals that most deaths in developing countries are preventable through the application of simple interventions. It is also apparent that some kinds of diseases lead to few deaths and yet they play a major role in depilating the population. Most populations in developing countries live in very poor environments and that is why the prevalence of most of the diseases are very high. The implication of this scenario is that the curative services only serves to prevent immediate deaths but the living environment remains the same and susceptibility to other attacks therefore remains.

The literature under review also reveals that 'shifts' in the main causes of death have been experienced in many countries and these shifts are mostly attributed to the levels of development, public health programmes, health policies and technological advancement in medicine. Whereas chronic and degenerative diseases are the major causes of death in developed countries, infective and parasitic diseases are the major causes of death in developing countries. A shift in major causes of death, particularly from infectious and parasitic diseases to chronic and degenerative diseases implies extension of life but long-term illnesses becomes more prevalent in the population.

Among the most prevalent specific causes of death, malaria remains the major specific cause of morbidity and death among all the age groups in Kenya. Apart from malaria, pneumonia and anaemia are other prominent diseases that are dominant causes of hospitalization in Kenyan health institutions among children. Accidents are also emerging as the major cause of death among males between the ages of 15 and 45 years.

2.5 Theoretical Framework And Analytical Models

The levels of mortality in populations have been estimated from both direct and indirect methods. Use of models is particularly important when the available data are limited and defective as in the Kenyan situation. The stable population theory provides a powerful tool for estimating population parameters where demographic data are deficient or erroneous.

A stable population has been defined to be the limit to which a population's age and sex structure tends to when subject to constant fertility and mortality (Lotka, 1911). The theory therefore depicts constant birth and death rates, a fixed age structure, a constant growth rate and it is closed to migration. The theory is based on the following assumptions:

i) the population is closed.

ii) c(x, t) , which is the proportion of persons alive within age x to x+dx is independent of time (t) i.e. c(x,t) = c(x).

iii) the survival function is independent of time i.e. $l_{(x,t)} = l_{(x)}$.

In a stable population, the total number of people, P_t, follows a simple exponential curve P_oe^{rt} and since the birth and death rates are constant, the annual number of births and deaths also follows an exponential curve:

$B_t = B_oe^{rt}$ and

$D_t = D_oe^{rt}$.

The age distribution of a stable population is given by

$c(a) = b.e^{-ra}l_{(a)}$ and

$N(a) = \int D^*(x)e^{(r(x-a))\,dx}$

where $D^*(x)$ is the true number of deaths experienced by those aged x in the current population (Preston et al., 1980).

Models available for assessing the completeness of adult death registration are based on the stable population theory. The models adjust the reported deaths to generate adjusted age-specific death rates. These models include the Brass Growth-Balance Method (Brass 1971), the Generalized Growth Balance Method (Hill 1987) and the Bennett Horiuchi technique (Bennett and Horiuchi 1984).

2.5.1 The Brass Growth Balance Model

The Brass Growth-Balance model assumes approximate stability of the population above each age and that deaths are under-reported by the same proportion for all the ages. The model is given as:

$$N(x)/ N(x+) = r + D^*(x+)/ N(x+) \text{ -----------(1)}$$

Where

N(x) = number of people of exact age x

N(x+) = Total number of persons aged x and over.

D*(x+) = Total number of deaths occurring to persons aged x and over

r = Population growth rate.

The ratio N(x)/N(x+) can be interpreted as a 'birth rate' for the population aged x and over, while D*(x+) /N(x+) is the death rate corresponding to the same population. In most of the districts in Kenya only a proportion of the deaths are recorded; thus; -

$D(x+) = c(x)D^*(x+)$, --------------------(2)

c(x) being a factor representing the completeness of death registration at age x and over. If the completeness of the death registration does not vary with age at least over age 5, c(x) can be replaced by c that does not vary with age. Substituting equation (2) in equation (1), we have: -

$$N(x)/N(x+) = r + k(D(x+)/N(x+) \quad \text{------------(3)}$$

Where $k = 1/c$

The relationship between D (x+) / N (x+) and N (x) / N (x+) is linear and the method makes no allowance for age misreporting, whether of age at death or for age of the living. Modifications of the model for mortality change leads to estimates of completeness in simulated populations that are more accurate than using the original Brass model (Linda G. Martin, 1980). The modifications, however, relies on fairly good knowledge of the duration and the rate of change of mortality, which is not available in Kenyan population. Furthermore, its applicability is limited to populations in which the rate of change of mortality has not varied too greatly.

The relationship between D (x+) / N (x+) and N(x)/N (x+) may be even or uneven and k is derived by choosing of the line that best fits the observed data. Distortions in data are principally due to misstatement of age, age dependent death registration or due to instability of the population considered.

2.5.2 Age-Specific Growth Rate Model

Bennett and Horiuchi (1981) developed a model that uses age-specific population growth rate. The model generates a life table that reflects the true mortality situation of the population under study from incompletely registered deaths. The theory exploits the fact that, in a stable population, the number of deaths to survivors aged x in a given year differs from that number in the previous year by a factor e^r. The model is an extension of the stable population theory but does not rely on the assumption of stability.

Based on the stable population theory, the model is generalized to:

$N(x) = \int D^*(x) \exp[r(x-a)]dx$ ------------- (1)

where $D^*(x)$ is the true number of deaths experienced by those aged x in the current population (Preston et al., 1980).

The model can be generalized such that it can be applied to any closed population, without requiring the restrictive assumption of stability (Bennett and Horiuchi, 1981).

In a stable population, the general equation is given as:

$N(x) = \int D^*(x)\exp[\int r(u)du]dx$ --------------------------(2)

Where r(u) is the rate of growth of the population aged u.

and $N^*(x)$ is defined as

$N^*(x) = \int D(x)\exp[\int r(u)du]dx$ ---------------------------(3)

where $N^*(x) = k\, N(x)$.

The probability of survival from age x to age n+ x is given as

${}_nP_x = N(n+x)/ N(x) \exp[\int r(u)du)]$ -------------------------(4)

Based on the assumption that death registration does not vary with age, we have

$_{n}p_{x} = N^*(n+x)/ N^*(x) \quad \exp[\int r(u)du)]$ ---(5)

Equation (5) in discrete form is given as:

$_{n}P_{x} = N^*(x+5)/ N^*(x) \exp(5_{5}r_{x})$ ----------------------------(6)

For computation, the analogous discrete form of equation (3) is given by

$N^*(x) = N^*(x+5)\exp[5_{5}r_{x}] + {}_{5}D_{x}\exp[2.5_{5}r_{x}]$ --------------------------(7)

where $_{5}r_{x}$ is the rate of growth of the population aged x to x+4 and $_{5}D_{x}$ is the number of registered deaths to persons aged x to x+4.

To adjust for biases in oldest ages, equation (7) is adjusted to become

$N^*(x) = N^*(x+5) \exp[5^*{}_{5}r_{x}] + {}_{5}\gamma_{x} {}_{5}D_{x}\exp[2.5^*{}_{5}r_{x}]$ -------------------- (8)

Adjustments to ages below 60 years is inconsequential and therefore for $x \geq 60$, we have

$_{5}\gamma_{x} = 1 - 2.26_{5}r_{x} . {}_{5}M_{x} + 0.218_{5}r_{x} - 0.826({}_{5}r_{x})$^2. ------------------(9)

In this study the adjustment will only be effected if it is found that it has an effect on the final results. The estimation procedure must start with finding N*(A), where A is the lower bound of the open interval. The relationship among D*(A+), e(A), r(A+) and N(A) is given as

N(A) = D*(A+)exp(r(A+)e(A)) – (r(A+)e(A)/6)^2 ------------------(10)

N*(A) = D(A+)exp(r(A+)e(A)) – (r(A+)e(A)/6)^2 ------------------(11)

In the estimation procedure, an alternative formula will be preferred to the above relationship.

The formula is given as:

$N^*(A) = D(A+)\exp(r(A+)*Z(A))$, -----------------(12)

where $z(A) = a(A)+b(A)+c(A)\exp(D(45+)/D(10+))$ and $r = r(A+)$ is the stable growth rate at age A and above, $D(45+)/D(10+)$ is the ratio of the recorded deaths over age 45 to the recorded deaths over age 10 and a(A), b(A) and c(A) are coefficients (see Appendix1). The above alternative method of estimating $N^*(A)$, proposed by Hill and Zlotnik (1982), does not rely on the National Model Life Tables to determine e(A) and that is why it was preferred in this study. Since we shall be comparing the census results against the results from these other methods, it is important that the results are independently derived.

Within each family of the Coale-Demeny model life tables, there is a one-to-one correspondence between the ratio of adolescent and younger adult deaths (ages 10 to 40), ${}_{30}d_{40}$, to older adult deaths (age 40 to 60), ${}_{20}d_{40}$, and the life expectancy at any age x, for x = 60 through 95 (Coale and Demeny, 1983). Because of the correspondence, we convert the age distribution ${}_5d_x$ of registered deaths into life table death distribution and this is done by noting that

$${}_5d_x = (1 / C.B)*{}_5D_x\exp[\int r(x)dx] \text{ ---------------------(13)}$$

where ${}_5d_x$ is the number of life table deaths at age 'x', C is the completeness of death registration, and B is the annual number of births in the population. The discrete analogue of the equation is

$${}_5d_x = (1/ C.B)*{}_5D_x\exp[5*\sum {}_5r_x + 2.5* {}_5r_x] \text{ ---------(14)}$$

When the values of ${}_5d_x$ are summed to form the ratio ${}_{30}d_{10} / {}_{20}d_{40}$, it is not necessary to know C and B since they cancel out. Once the ratio is computed, we refer to the appropriate family of model life tables for the corresponding e(A) value, which may be obtained by interpolation (See Appendix 1).

2.6 Study Hypotheses

The focus of this study is the application of the Brass Growth Balance method and the Bennett-Horiuchi method to estimate completeness of death registration and construct mortality life tables and hence no hypothesis will be tested.

2.7 Definition of Key Variables In The Analytical Models

The study used the following variables in the analysis:

Age

Age was considered to be a person's number of years lived as of the time of the event in completed years. The ages were categorized into five-year age group.

Number of Deaths

This was the number of deaths that occurred and were registered in the year 1999.

Cause of Death

This is the underlying cause of death as recorded on the death certificate. The coding was done according to International Classification of Diseases (ICD).

Population (1999)

This was the number of persons enumerated on the night of 24/25, August 1999 by sex and age group. The population was enumerated on de facto basis.

Age at Death

This is the number of completed years at the time of death of the decedent and was categorized into five-year age groups.

Age Specific Growth Rate

This is the population growth rate calculated from the 1989 and 1999 population censuses for age group x to x+4.

Partial Births/Deaths

Partial birth rates are interpreted as a 'birth rate' which is the number in the population entering age x and over while partial death rates are interpreted as 'death rate' corresponding to the same population.

Adjustment factor

This is a factor that adjusts the number of deaths in a population depending on the completeness of registration.

Completeness

This is the level of death registration in the population relative to the 1999 census.

CHAPTER 3
DATA AND METHODS OF ANALYSIS

3.1 Sources of data

The sources of data in this study are the 1989 and the 1999 population and housing censuses conducted on the 24th/25th , August,1989 and 1999 respectively. This study also uses the death registration data captured between October, 2002 and May, 2003. The exercise was a collaborative effort between the departments of Civil Registration and the Central Bureau of Statistics with financial support from·UNICEF.

3.2 Quality of data

The three districts were targeted for this study because the department of civil registration was interested in assessing the performance of the registration system in districts thought to have a reasonably good coverage in the registration of births and deaths. For the registration of the deaths, the department uses two different forms (D1 and D2), depending on where the death occurred. Form D1 captures deaths that occur in health institutions while form D2 is used to capture deaths that occur outside health institutions.

While forms D1 are filled up by the health personnel, form D2 are mostly administered by chiefs and assistant chiefs in the rural areas. Thus, the quality of data capture in form D1 would be expected to be more reflective of the true structure of the causes of death in the respective districts than the information captured on the other form D2. Inaccurate reporting of causes of death and age puts limitations on the analysis of levels and trends of mortality at the district and national levels. Deaths are also a result of a series of conditions and it is therefore difficult to ascertain which condition takes precedence as the underlying cause.

Censuses also suffer from both content and coverage errors. Age misreporting, missed out sections of the population and failure to record basic characteristics of the population have been observed in the past censuses carried out in Kenya. In Kenya, the United Nations accuracy index was estimated at 28.1, 24.9 and 26.4 in 1979, 1989 and 1999 respectively (CBS, 1999). In 1999 the indices of misreporting i.e. the Whipple's index, Myer's index and Bachi index were estimated at 1.5, 14.7 and 10.2 respectively. The census under-coverage was estimated to be 0 percent, 2.8 percent, 6.0 percent and 2.7 percent in 1969, 1979, 1989 and 1999 respectively.

3.3 Methodology

This section outlines the mathematical models used to analyze the data.

3.3.1 Life Table

The life table is a statistical device used to present the mortality experience of a population. The life table is also a demographic tool that has a variety of applications beyond the analysis of mortality. It is used in mortality studies to calculate the average expectation of life at different ages; which is an index of the additional number of years.

It is also possible to divide the decrements by death in the life table into components according to specified causes of death. This makes it possible to calculate the probability of ultimately dying from a specified cause and also the increase in expectation of life made possible by eliminating any of the causes of death. Multiple-decrement life tables therefore analyze two or more types of attrition operating together. In this study we analyze mortality by examining some functions of the life table such as life expectancy at birth and the survival of the population at different ages. We also look at the cause-of-death by estimating the increase in the expectation of life resulting from the elimination of a particular cause of death.

The mortality rate ($_nq_x$), which is the probability of dying within n years after attaining age x, is the most fundamental column of the life table and it is estimated by:

$_5q_x = 5\ _5M_x / (1+5/2\ _5M_x)$

This formula only approximates the actual probability of death and it assumes that the deaths are distributed evenly over the age interval and therefore the deaths occur halfway in the interval. At the younger ages, below 4 years, the approximate fractions used are 0.1 for ages 0 to 1 and 0.4 for ages 1 to 4 (Chiang, 1984).

$_nM_x$ is a central rate, which forms the basic data from which life table analysis begins.

To compute the age-and-cause specific death rates in this study, we shall use the number of deaths from each cause by age group.

If $_nD_{x,\alpha}$= Observed number of deaths in age group (x, x + n) due to cause C_α

and $_nN_x$ = mid-year base population, then

$_nM_x = (_nD_{x,\alpha} / _nN_x)$

$_nM_x$ is the observed mortality rate in the population.

The cause-of-death ratio = $_nD_{x,\alpha} / _nD_{x,+}$

l_x denotes the survivors of a cohort of live born babies to the exact age x. The initial value of the survivors column is l_0 (the radix).

$_nd_x$ denotes the deaths experienced by the life table cohort within the interval x to x+ n.

$_nd_x = l_x - l_{x+n}$

$_nL_x$ shows the number of person-years lived by the cohort during the interval between specified birthdays i.e. between x and x+ n years.

$_nL_x = n/2(l_x + l_{x+n})$.

$L_0 = 0.25l_0 + 0.75\ l_1$

$L_1 = 1.9\ l_1 + 2.1\ l_5$

$_5L_0 = L_0 + L_1$

$T_x = T_{x+n} + {}_nL_x$

$e_x = T_x / l_x$

3.3.2 The Brass Growth Balance Method

The Brass Growth Balance method assumes that the population under study is demographically stable (Brass, 1975) and it also assumes that death registration completeness is not age-dependent. The slope of the relationship between the partial birth rates and the partial death rates is used to estimate the completeness of death registration and gives an adjustment factor for the number of deaths. This section therefore focuses on the computation procedures.

Computational Procedures

Step1: The person-years lived by the population subject to the risk of dying.

The step involves adjusting the reported population to the mid-point of the period for which death data is available. The adjusted population values are computed as: -

$_5N_x^{adj}(x) = {}_5N_x(x)\, e^{(r(t_m - t_c))}$

where

t_m = Date corresponding to the middle of the period (1999) to which death data refer i.e. 1, July, 1999. The difference in time between 1, July and 24, August is 55 days or 0.1506 of a year.

t_c =Reference date of the census i.e. 24, August, 1999.

Step 2: Calculation of the population at an exact age.

If ${}_5N_X\,(x)$ is the number of persons in the age group from x to x+4 at the time of the census, then N(x) is estimated as:

$$N(x) = ({}_5N_{X-5}(x) + {}_5N_X(x))/10$$

Step 3: Calculation of population over an exact age:

$$N(x+) = \sum {}_5N_j + N(A+)$$

Where

N (A+) = Number of persons in the last open-ended age interval.

Step 4: Calculation of the number of deaths after an exact age.

D (x+) is the total number of deaths recorded as having occurred to persons aged x and over.

$$D(x+) = \sum {}_5D_j + D(A+)$$

Where D(A+) = Number of deaths in the open-ended age interval A and over.

Step 5: Point defined by partial death and birth values.

The values D(x+) /N(x+) and N(x) /N(x+) are displayed graphically, plotting the values of D(x+) / N(x+) on the x-axis and those of N(x)/N(x+) on the y-axis.

Step 6: Selection of a best fitting line.

Several methods can be used to fit a straight line to a series of points. The most widely used method is the 'least squares' method. However, given the inaccuracies typically present in population and death registration data, the use of other methods of fitting are preferred in this study. The "mean" line method which involves getting the means of the abscissa and ordinates of the derived points when those points are divided according to age, into two sets of approximately equal size will be applied. The desired line is that which passes through the two points defined by the two pairs of mean co-ordinates.

Step 7: Adjustment of death rate:

The adjustment factor, k, and the growth rate, r, are derived from the slope and the y-intercept respectively. The value of the completeness of death registration is c =1/k. The adjusted death rate is obtained by multiplying reported death rate by k.

3.3.3 Age-Specific Growth Rate Method

The Bennett-Horiuchi method uses age-specific growth rates for two consecutive censuses to derive an age distribution from the age distribution of registered deaths. The method assumes that the population is closed and death registration does not depend on age. This section therefore gives the procedures to be followed to estimate the completeness of death registration.

Computational Procedures

Step 1: Calculation of life table age distribution.

From the equation ${}_5d_x = (1/ C.B)*{}_5D_X \exp(5*\sum{}_5r_x + 2.5*{}_5r_x)$ we have

$(C.B)\ {}_5d_x = {}_5D_X \exp(5\sum{}_5r_x + 2.5{}_5r_x)$

Step2: Calculation of e(A).

Compute ${}_{30}d_{40}/{}_{20}d_{40}$ from step1. C.B cancels out in the ratio. From appendix1 tables we determine the corresponding values of e(60) through e(95).

Step3: Calculation of N*(A).

Determine the value of N*(A) using the formula

$N^*(A) = D(A)\exp(r(A+)*z(A))$

Step4: Compute N*(x) from the formula

$N^*(x) = N^*(x + 5) \exp(5{}_5r_x) + {}_5D_x \exp(2.5{}_5r_x)$ for x<60 if the adjustment factor has no significant effect on the final results.

Step5: Calculation of ${}_5p_x$.

Compute ${}_5p_x$'s using the formular

${}_nP_x = N^*(x+ 5)/ N^*(x) \exp(5{}_5r_x)$.

CHAPTER 4

BACKGROUND CHARACTERISTICS OF THE STUDY POPULATION

4.0 Introduction

This chapter looks at the characteristics of the study population in the three districts. These characteristics include the population size by sex for the years 1989 and 1999, mortality, fertility and epidemiological characteristics. Frequency distributions of the number of deaths according to sex, month of death, year of death, place of death, occupation and the major causes of death are also presented by district.

4.1 Demographic characteristics

Demographic factors like age and sex are known to contribute to the risks of death in the population. This section therefore looks at the demographic characteristics of the population in the three study districts and at the National level.

4.1.1 Population size, Structure and Growth

Tables 4.1 and 4.2 presents the population size and structure by sex in 1989 and 1999 for each of the study districts. Figures 4.1, 4.2 and 4.3 are pyramids illustrating the age-sex distributions in Nairobi, Nyeri and Bungoma in 1999. It is evident from figure 4.1 that the Nairobi age structure does not follow the typical pattern where the population at the younger ages is large for each sex and diminishes in the subsequent age groups. Three factors are important in determining the shape of this pyramid i.e. fertility, mortality and migration. The pyramid narrows at the base and bulges in the middle, which implies migration is possibly the most important demographic factor. The bars for age groups 20-

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30 bulges particularly for males, which suggests heavy migration. The figure shows the dominance of males over females in this age range. There was however a relatively smaller number of children and those in old age in the Nairobi population.

Table 4.1 Population Distributions, 1989

	Nairobi		Nyeri		Bungoma	
Age	Male	Female	Male	Female	Male	Female
0-4	88825	87102	46249	45150	56743	57176
5-9	65277	67734	48985	48224	46468	49993
10-14	49676	56771	45542	44949	39550	40111
15-19	55784	71978	36698	36568	31998	32423
20-24	118153	94582	26561	30665	20693	24148
25-29	120344	74949	20017	23486	16388	19691
30-34	80959	41606	12853	14147	13180	14579
35-39	57589	28419	11162	12632	9603	10846
40-44	41910	17211	10111	11395	7716	8363
45-49	27530	10457	7860	9715	5590	6546
50-54	19173	6669	6637	7858	5037	5526
55-59	9898	3881	4800	5475	4282	4718
60-64	5392	3181	4516	5852	3336	3436
65-69	3136	1924	3792	4316	2393	2773
70-74	1657	1378	2829	3582	1756	1986
75-79	1102	981	2683	2866	1298	1278
80+	1062	1496	3620	5115	1456	1658
NS	5130	1654	196	186	198	184
Total	752597	571973	295111	312181	267685	285075

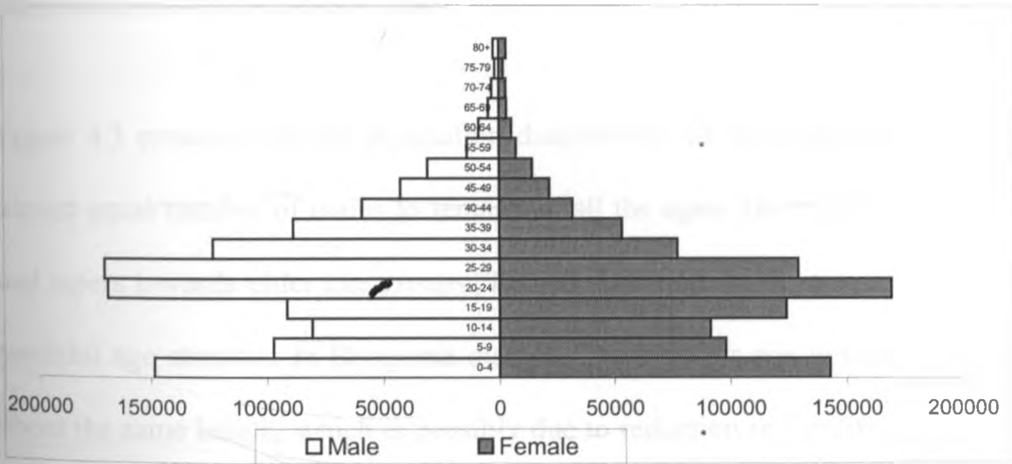
Source: 1989 Population Census Vol. 1

Table 4.2 Population Distributions, 1999

	Nairobi		Nyeri		Bungoma	
Age	Male	Female	Male	Female	Male	Female
0-4	148574	142896	41250	39964	84160	83414
5-9	97322	98165	38371	37704	67074	67659
10-14	80587	91473	46216	45505	64160	65606
15-19	91437	124129	40832	39708	52283	53459
20-24	168926	169108	30646	33051	36336	42157
25-29	170343	129226	24940	28383	26324	30425
30-34	123360	77397	21172	23588	20524	23554
35-39	88712	53277	17449	19339	18204	20393
40-44	59224	31866	11202	12424	14285	15729
45-49	42817	21706	10074	11555	10891	12100
50-54	30961	14318	10050	11042	8259	9240
55-59	13963	7351	6514	7895	5897	6913
60-64	8829	5338	5868	7169	5296	5914
65-69	4697	3236	4067	5108	4375	4974
70-74	3247	2948	3989	5060	3200	3282
75-79	1862	1750	2790	3321	2094	2474
80+	2513	2981	3811	5859	1925	2620
NS	16454	12261	3278	1960	670	621
Total	1153828	989426	322519	338635	425957	450534

Source: 1999 Population Census Vol. 1

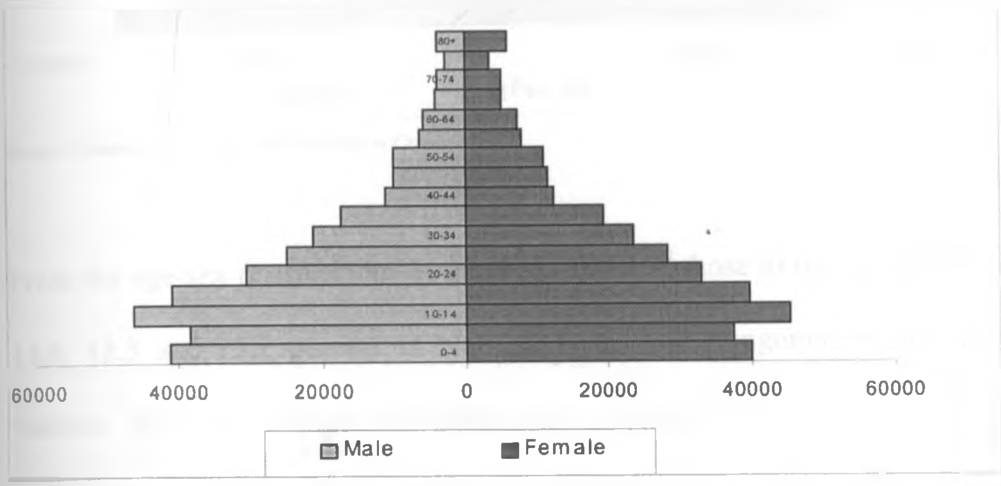
Fig.4.1: Population Distribution in Nairobi, 1999



Source: Generated from the 1999 Population.

The age-sex distribution in Nyeri district is presented in figure 4.2. The figure narrows at the base and bulges out at age group 10-14. Drastic increases in the levels of infant and child mortality can cause a reduction in the numbers of children surviving while reductions in birth rates may lead to a decrease in the number of children being born and therefore recent cohorts being smaller than the preceding ones. The behavior in the Nyeri data may therefore be attributed to either drastic changes in mortality or fertility, or drastic changes in both fertility and mortality. Another characteristic of the Nyeri data could be age misstatement or undercounts at the younger ages.

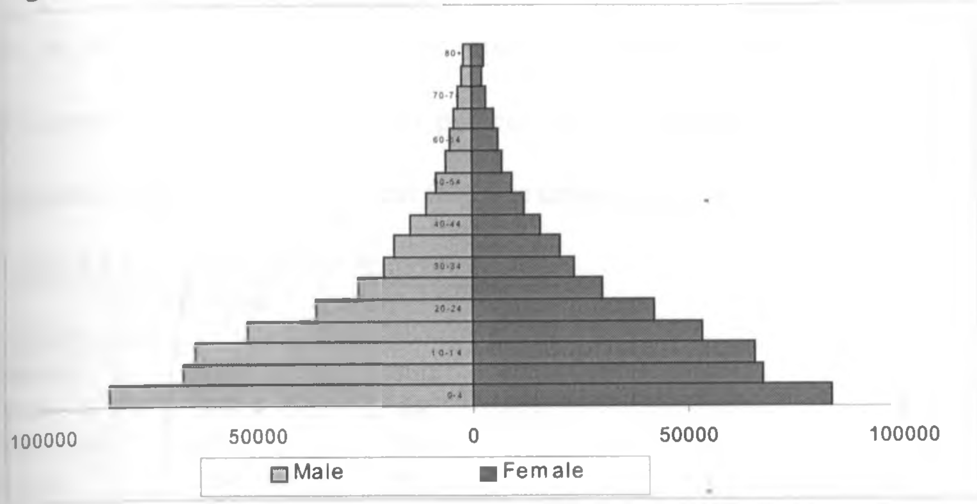
Fig.4.2 Population Distribution in Nyeri, 1999



Source: Generated from the 1999 Population Census.

Figure 4.3 presents age-sex population distribution for Bungoma district and shows an almost equal number of males to females at all the ages. The figure depicts a broad base and tapers towards older age groups. This implies high birth rates and death rates and a youthful age structure in Bungoma district. The bars for age groups 5-9 and 10-14 are about the same length, which is possibly due to reduction in fertility for the age group 5-9, age misreporting or under enumeration.

Fig.4.3: Population Distribution in Bungoma, 1999



Source: Generated from the 1999 Population Census.

From the age-sex distributions in the three districts, those in the age group 0-4 represents 13.6, 12.3 and 19.1 percent in Nairobi, Nyeri and Bungoma districts respectively. In Nairobi, Nyeri and Bungoma districts, those in age bracket 0-14 years represent 31, 38 and 49 percent of the total population respectively. This implies that Bungoma district has a younger population as compared to Nairobi and Nyeri districts. The proportion in the 0-4 age bracket for Nairobi and Nyeri are more or less the same while those in age bracket 0-14 indicates a slight difference. The proportion in the advanced age bracket (65+) shows that Nyeri had a higher proportion of about 5 percent while Bungoma and Nairobi had 1.08 and 2.85 percent respectively. The proportions of the young and the old in the population have social, economic and health implications on society.

Table 4.3 presents the population growth rates and the proportions of the population that are Urban at the district and National levels. Nairobi and Bungoma districts had population growth rates that were above the National level and the growth rate for Nyeri was below one percent. Nairobi's high population growth rate is due to Rural-Urban migration while the high population growth rate experienced in Bungoma is basically due to the high fertility levels in the district. Nairobi is wholly urban while Nyeri and Bungoma had about 39 and 30 percent urban population respectively. The estimated national proportion of 19 percent that was urban could probably be an underestimate.

Table 4.3 Growth rates and Proportion Urban

District	Growth Rate (%)	Urban Population (%)
Nairobi	4.86	100
Nyeri	0.8	39
Bungoma	4.59	30
Kenya	2.90	19.4

Source: 1999 Population Census Vol. 1&2

4.1.2 Fertility

Table 4.4 presents Total Fertility Rates (TFR) and Crude Birth Rates (CBR) at the district and National levels for the 1979-1989 and 1989-1999 periods. It is evident that all the districts experienced reductions in both TFRs and CBRs. The reductions were also experienced at the National level. Whereas the TFR at the national level decreased by 24.2 percent, Nairobi, Nyeri and Bungoma experienced reductions of 21.2, 29.6 and 21.0 percent respectively. Bungoma district exhibits TFR that was about twice the TFR experienced in Nairobi and Nyeri.

The CBRs reduced by 10.6, 22, 16 and 14 percent in Nairobi, Nyeri, and Bungoma and at the National level respectively. It will be noted from the data that while TFR for Nairobi is lower by 27 percent of the TFR in Nyeri, a comparison of the CBRs indicates that Nairobi had a higher crude birth rate by about 10 percent. This demonstrates the effects the age structure has on CBRs. High fertility levels have implications on maternal and childhood mortality and hence on the overall mortality levels in the population.

Table 4.4 Fertility Levels, 1989 and 1999.

	TFR		CBR	
District	1989	1999	1989	1999
Nairobi	3.8	3.0	35.8	32.0
Nyeri	5.4	3.8	37.7	29.4
Bungoma	8.1	6.4	55.3	46.6
Kenya	6.6	5.0	48.0	41.3

Source: 1999 Population and Housing Census Vol:IV

4.1.3 Mortality

Table 4.5 presents the total number of deaths by sex and district. The number of recorded deaths in Nairobi decreased from age zero to age group 10-14 for both sexes and then increased from age group 15-19 to age group 35-39 for males and 30-34 for females. From age group 40-44 for males and 35-39 for females, the number of recorded deaths once again shows a decreasing trend. In Bungoma, the number of deaths doesn't show any particular trend, except for the high number of deaths at the younger and older ages for both males and females. However, their was an elevation in the number of recorded deaths at age groups 35-39 for males and 25-29 for females. For Nyeri, the number of recorded deaths decreased from childhood to age group 10-14 and then increased up to age group 35-39.

Within the reproductive age groups (15-49), the number of recorded deaths among females showed an upward trend in all the districts. In Nairobi, the number of recorded deaths among females surpassed the number of recorded deaths among males from age group 15-19 to 25-29. In Nyeri district, the number of recorded deaths among females was similar to the number of recorded deaths among males in the age groups 15-19 to 20-

24 but at age group 25-29 the number of recorded deaths among females surpassed the number of recorded deaths among males. From age group 30-34 to 45-49, the number of recorded deaths among males was more than the number of recorded deaths among females. In Bungoma, the number of recorded deaths among males and females was similar in age groups 15-19 and 20-24. At age group 25-29, the number of recorded deaths among females was more than the number of recorded deaths among males. For age group 30-49, more males than females deaths were registered in Bungoma district.

In all the districts, the deaths registered in age group 0-4, a higher number of male deaths than female deaths were registered. Overall, more males than females were registered and this phenomenon may be attributed to higher mortality levels among males than females and cultural factors that may hinder complete registration among females. It is also possible that the department of civil registration has poor record keeping practices and thus some of the records may not have been captured. However, the existing by-Laws in urban areas, particularly in Nairobi, imply that cultural factors may not be the major reason for these differences.

Table 4.5 Distribution of Number of Deaths By Age, Sex and District

	Nairobi			Bungoma		Nyeri	
Age	Male	Female	NS	Male	Female	Male	Female
0-4	2186	1822	16	581	496	270	214
5-9	226	195	2	101	83	31	23
10-14	108	120	1	67	51	15	9
15-19	188	229	3	51	50	27	24
20-24	385	492	1	55	50	51	51
25-29	652	693	5	73	89	56	76
30-34	797	620	9	57	56	102	98
35-39	782	490	3	80	73	102	90
40-44	629	335	2	62	59	69	44
45-49	548	271	4	64	36	74	49
50-54	395	210	2	54	37	84	52
55-59	277	149		41	36	57	39
60-64	262	156	2	49	36	78	61
65-69	179	119		42	32	69	41
70-74	174	140	1	64	36	114	67
75-79	131	109		46	32	85	66
80+	462	378	4	292	277	233	283
Total	8381	6528	55	1779	1529	1517	1287

Source: Departments of Civil Registration and CBS, 1999.

Table 4.6 shows mortality levels and trends for different periods at the National and district levels. All the indicators of mortality show that mortality has been increasing in the last decade at both the district and National levels. Whereas expectation of life at birth, $e_{(0)}$, have reduced at both the district and National levels, Crude Death Rates, Infant Mortality Rates and Under-5 Mortality have increased.

During the 1989 to 1999 period, Infant Mortality in Nairobi remained constant whereas it increased by 30 and 5 percent in Nyeri and Bungoma districts respectively. At the National level, Infant Mortality increased by about 10 percent. Life expectancy at birth decreased by 14, 8, 3 and 9 percent in Nairobi, Nyeri, Bungoma and at the National level respectively. Nairobi thus experienced a very high drop in the life expectancy at birth as compared to the National average. An interesting finding from these results is that Bungoma district experienced the lowest drop in expectation of life at birth of 3 percent.

The Crude Death Rate in Bungoma district in 1989 was about twice the rates in Nairobi and Nyeri districts but about the same as the National rates. By 1999, the differences between the Crude Death Rates in Bungoma and the other districts had narrowed markedly though the Bungoma rates were still above the National average. Whereas the Crude Death Rates increased by 9 percent between 1979/1989 and 1989/1999 in Bungoma district, Nairobi and Nyeri districts had increases of 72 and 41 percent respectively. At the National level, the Crude Death Rates increased by 10 percent. Nairobi and Nyeri districts have therefore experienced the highest mortality upturns, which could probably be attributed to deteriorating environmental, economic, social and epidemiological conditions in the two districts. It is also apparent that the differences that existed between urban and rural areas, with the urban areas having an advantage, are being wiped out.

Table 4.6 Mortality Indicators

	e(o)		CDR		IMR		Under-5 Mortality	
District	1989	1999	1989	1999	1989	1999	1989	1999
Nairobi	66.1	57	5.4	9.3	49	49.7	75	93
Nyeri	69.5	63.9	6.9	9.7	21	27.2	37	53
Bungoma	59.8	57.9	11.3	12.3	92	97	140	145
Kenya	61.9	56.6	11.7	11.7	70.1	77.3	113	116

Source: Kenya population & Housing Census, 1999, Vol.V

Table 4.7 shows the total number of deaths registered in 1999 by the year of occurrence for each of the districts. The total number of deaths registered in 1999 was more than the number of deaths that occurred in the same year, mainly due to late registration. Nairobi had a late registration of 5 percent while Nyeri and Bungoma districts had 5.5 and 19.6 percent late registration. This means that about 20 percent of the deaths in Bungoma district were not registered immediately after they occurred.

Table 4.7 Number of Deaths by Year of Death and District

	Nairobi		Nyeri		Bungoma	
Year of Death	Frequency	%	Frequency	%	Frequency	%
1999	14964	95	2826	93.1	3312	78.7
Other	768	4.9	165	5.5	824	19.6
NS	13	0.1	44	1.4	70	1.7
Total	15745	100	3035	100	4206	100

Source: Derived from Death Registration data, 1999.

Table 4.8 shows the distribution of the number of deaths by district of residence. Thirty-nine percent, 87.8 and 89.5 percent of the deaths that were registered in Nairobi, Nyeri and Bungoma districts respectively were residents in the district of study. Whereas about 10 percent of the deaths registered in Nyeri and Bungoma districts were non-residents, 60 percent of the deaths registered in Nairobi were non-residents of Nairobi. This large number of non-residents, particularly for Nairobi, biases the mortality estimates upwards. A large number of the deaths registered in Nairobi are of people who may have been exposed to different risks and thus when these deaths are registered in Nairobi they may distort the structure of diseases.

Evidently, neighboring districts have an impact on the number of deaths that occur in a given district, and more so for Nairobi. Of the total number of deaths in Nairobi in 1999, 23 percent were residents of the neighboring districts while 32 percent of the deaths were to people from other districts. In Nyeri and Bungoma districts, 8.4 and 7.4 percent respectively were from neighboring districts. These exceptional characteristics for

Nairobi could be attributed to the availability of referral facilities, mortuary services and the concentration of the medical personnel in urban centers.

Table 4.8 Number of Deaths and District of Residence

	Nairobi		Nyeri		Bungoma	
District of Residence	Frequency	%	Frequency	%	Frequency	%
District of Study	5887	39.0	2482	87.8	2964	89.5
Neighboring Districts	3424	23.0	236	8.4	245	7.4
Others	4715	32.0	108	3.8	91	2.8
NS	938	6.0	0	0.0	12	0.3
Total	14964	100	2826	100	3312	100

Source: Derived from Death Registration Data, 1999

4.2. Epidemiological Characteristics

Epidemiology is concerned with the patterns of occurrence of diseases and the factors that influence suck patterns. Different diseases are caused by a combination of risk factors and have varying effects on sex and age in a population. Social, economic, environmental, cultural and demographic factors therefore determines the prevalence of diseases in different geographic areas.

Table 4.9 presents the distribution of specific causes of death in each of the three districts. Pneumonia, HIV/AIDS, malaria, and tuberculosis were the leading specific causes of death in the three districts. Whereas pneumonia was the leading killer in Nairobi and Nyeri districts, malaria accounted for 40 percent of the deaths in Bungoma district. HIV/AIDS accounted for about 10 percent of the total deaths in Nairobi and Nyeri districts but accounted for only 4.0 percent of the deaths in Bungoma district. The low HIV/AIDS prevalence rates in Bungoma district may be attributed to the fact that most deaths occur at home might affects the accuracy of reporting the cause of death.

Table 4.9 Major Causes of Death

	Nairobi	Nyeri	Bungoma
Cause of Death	%	%	%
Pneumonia	12.6	17.2	11.8
HIV/AIDS	9.0	10.4	4.0
Tuberculosis	8.8	2.9	3.8
Malaria	6.0	7.5	40.4
Gastroenteritis	5.7	0.8	1.0
Meningitis	4.4	1.0	0.5
Heart Failure	3.4	3.5	0.7
Dehydration	2.7	0.5	0.5
Road Traffic Accidents	2.6	0.8	1.2
Pre-maturity	2.6	1.4	0.1
Hypertension	2.2	1.3	0.4
Anaemia	2.1	1.3	5.9
Respiratory Failure	2.0	1.8	0.3
Sepsis	1.9	0.7	0.4
Asphyxia	1.8	2.7	0.3
Stroke	1.6	6.3	2.1
Malnutrition	1.0	0.5	2.1
Stomach Cancer	0.5	1.6	0.1
Measles	0.6	1.3	2.3
Pregnancy/Child Birth	0.2	0.5	1.2
Typhoid	1.1	0.5	1.1
Other	27.2	35.5	19.8
Total	14964	2826	3312

Source: Derived from Death Registration Data, 1999

Table 4.10 presents the distribution of deaths by broad categories. In all the three districts, infectious and parasitic diseases were the leading cause of death. In Nairobi, Nyeri and Bungoma districts, infectious and parasitic diseases accounted for 28.3, 24.9 and 53.4 percent respectively of the total deaths. Thus, whereas about a quarter of the deaths in Nairobi and Nyeri districts were attributed to infectious and parasitic diseases, over half of the deaths in Bungoma district were attributed to this group of diseases.

Diseases of the Respiratory System were the second major causes of death in the three districts and accounted for 16.8, 22.6 and 13.3 percent of the total deaths in Nairobi, Nyeri and Bungoma districts respectively. The proportion of deaths attributed to diseases of the respiratory system in Nyeri district was almost twice the proportion in Bungoma district. The high prevalence of deaths attributed to Respiratory diseases in Nyeri district may be attributed to the extremely cold weather conditions during some months due to its proximity to Mount Kenya.

Malignant Neoplasm accounted for 5.4, 7.0 and 3.5 percent of the total number of deaths in Nairobi, Nyeri and Bungoma districts respectively. Degenerative and chronic diseases are associated to the levels of development and the age structure of the population. The results imply that Nyeri district has a higher proportion of the aged as alluded to earlier in section 4.1.1. Road traffic Accidents are also emerging as a major cause of death and are high in Nairobi due to the high concentration of traffic.

Table 4.10 Cause of Death By Broad Categories

	Nairobi		Nyeri		Bungoma	
Cause of Death	Frequency	%	Frequency	%	Frequency	%
Infectious and Parasitic Diseases	4233	28.3	704	24.9	1768	53.4
Malignant Neoplasm	804	5.4	.199	7.0	117	3.5
Endocrine, Nutritional and Metabolic Diseases	852	5.7	104	3.7	100	3.0
Diseases of the Nervous System	847	5.7	72	2.5	28	0.8
Diseases of the Circulatory System	1294	8.6	363	12.8	127	3.8
Diseases of the Respiratory System	2519	16.8	638	22.6	440	13.3
Diseases of the Digestive System	1296	8.7	91	3.2	82	2.5
Pregnancy, Child Birth and Puerperum	118	0.8	32	1.1	53	1.6
Road Traffic Accidents	389	2.6	22	0.8	40	1.2
Others	2507	16.8	523	18.5	472	14.3
NS	105	0.7	78	2.8	85	2.6
Total	14964	100	2826	100	3312	100

Source: Derived from Death Registration Data, 1999

Geographic residence appears to play an insignificant role in terms of the leading causes of death since the cause-of-death profiles for the three districts are generally the same.

For purposes of allowing us maximize simplicity, we restricted the number of specific causes of death to just a small number. It was also realized that, though death registration is administered under two different regimes, forms D1 and D2, the general profile of the diseases did not change significantly when combined.

Omran (1971) proposed the concept of 'epidemiological transition' accompanying mortality decline. In the framework, under high, pretransition mortality the major causes of death are the major infectious and parasitic diseases, which include typhoid, cholera, typhus, measles, diphtheria, whooping cough and smallpox. The intermediate mortality levels are characterized by non-epidemic infectious diseases, which are predominated by pneumonia, bronchitis, tuberculosis and enteritis. According to Omran, as these diseases in the intermediate levels are brought under control, leading causes of death shift to the degenerative and chronic diseases of old age. It is obvious that the three districts are in the intermediate stage where non-epidemic infectious diseases reign supreme. However, there are marked differences between Bungoma and the other two districts because of differences in demographic, social, economic, environmental and health care factors.

Table 4.11 shows the number of deaths by the month of occurrence. In Nyeri district, the months of March, April, August, September, October, November and December had a high number of deaths as compared to the months of January, February, May, June and July. The months of May, June and July presented the lowest number of deaths in the whole year. Nairobi district experienced the least number of deaths in the month of December while the highest number of deaths was experienced in the months of May, June and July. Bungoma district had the highest number of deaths in the month of July and the lowest number in the month of December.

Environmental factors may probably be responsible for the seasonal variations in the observed patterns of death in the three districts. Rainfall, relative humidity, temperatures and morbidity are key factors that may have contributed to the observed variations.

Table 4.11 Number of Deaths By Month

	Nairobi		Nyeri		Bungoma	
Month of death	Frequency	%	Frequency	%	Frequency	%
January	1288	8.6	193	6.8	282	8.5
February	1193	8.0	194	6.9	274	8.3
March	1306	8.7	350	12.4	310	9.4
April	1385	9.3	279	9.9	378	11.4
May	1558	10.4	88	3.1	343	10.4
June	1603	10.7	132	4.7	344	10.4
July	1359	9.1	129	4.6	425	12.8
August	1388	9.3	319	11.3	214	6.5
September	993	6.6	327	11.6	273	8.2
October	1281	8.6	306	10.8	299	9.0
November	1211	8.1	230	8.1	147	4.4
December	394	2.6	274	9.7	23	0.7
NS	5	0.0	5	0.2	0	0.0
Total	14964	100.0	2826	100	3312	100.0

Source: Derived from Death Registration Data, 1999

Tables 4.12 and 4.13 presents the number of deaths by occupations for males and females respectively. The occupation of an individual reflects on his or her exposure to risks of death. The social status of the household head, which may be measured by his/her occupation, also affects the whole family. Income and education of an individual are other important aspects of his or her occupation. Education exposes an individual to the knowledge of minimizing the risks of diseases and income offers the capability for cure.

The highest number of deaths in Nairobi and Bungoma districts was among those aged less than 10 years for both males and females. In Nyeri district, the highest number of deaths was among those aged less than 10 years for females and among the males the highest number of deaths were farm workers. Females in the teaching profession also had a proportionately high number of deaths in Nyeri district. Nairobi had the highest number of deaths among housewives (16 percent) whereas Nyeri and Bungoma had proportions of 13.1 and 12.2 percent respectively. Subsistence farmers also suffered proportionately high numbers of deaths in Nyeri and Bungoma districts.

Completeness of the information recorded on death certificates is an indicator of the quality of data from civil registration. The data reveals that high proportions of the occupation for the dead were not recorded. Over 20 percent of the deaths did not have their occupations declared in the death certificates with Nairobi leading with a percentage of 33.1 and 32 percent of the males and females respectively with occupations not recorded. This phenomenon makes it difficult to determine the social status of an individual and his/her risks of dying.

Table 4.12 Occupation Males

	Nairobi		Nyeri		Bungoma	
Occupation	Frequency	Percent	Frequency	Percent	Frequency	Percent
<10 Years	2153	25.7	284	18.7	686	38.8
Business Profession	530	6.3	60	4.0	24	1.4
Unemployed	506	6.0	22	1.5	49	2.8
Retired	264	3.1	7	0.5	8	0.5
Armed Forces	166	2.0	10	0.7	10	0.6
Services and Sales	145	1.7	14	0.9	16	0.9
Drivers	144	1.7	28	1.8	12	0.7
Farm Workers	142	1.7	294	19.4	64	3.6
Student	138	1.6	24	1.6	45	2.5
Labourers (Construction)	92	1.1	20	1.3	4	0.2
Other Profession	91	1.1	10	0.7	4	0.2
Agriculture (Subsistence)	72	0.9	218	14.4	233	13.2
Labourer (Agriculture)	33	0.4	5	0.3	37	2.1
Technicians	72	0.9	19	1.3	6	0.3
Teaching	57	0.7	18	1.2	16	0.9
Other	1000	11.9	165	10.9	86	4.9
NS	2776	33.1	319	21.0	467	26.4
Total	8381	100.0	1517	100.0	1767	100.0

Source: Derived from Death registration Data, 1999

Table 4.13 Occupation Females

	Nairobi		Nyeri		Bungoma	
Occupation	Frequency	Percent	Frequency	Percent	Frequency	Percent
<10 Years	1823	27.9	209	16.2	628	41.2
Housewife	1044	16.0	169	13.1	186	12.2
Unemployed	412	6.3	18	1.4	52	3.4
Business Profession	247	3.8	53	4.1	9	0.6
Retired	118	1.8	21	1.6	6	0.4
Student	99	1.5	16	1.2	41	2.7
Teaching	59	0.9	199	15.5	5	0.3
Farm Worker	61	0.9	192	14.9	28	1.8
Agriculture (Subsistence)	28	0.4	10	0.8	112	7.4
Labourer (Construction)	10	0.2	0	0.0	0	0.0
Labourer (Agriculture)	8	0.1	5	0.4	13	0.9
Services and Sales	47	0.7	6	0.5	0	0.0
Others	455	7.0	84	6.5	37	2.4
NS	2116	32.4	306	23.8	406	26.7
Total	6528	100.0	1288	100.0	1523	100.0

Source: Derived from Death registration Data, 1999

CHAPTER 5
ESTIMATION OF COMPLETENESS OF DEATH REGISTRATION AND LEVELS OF MORTALITY

5.0 Introduction

In this chapter we estimate the completeness of death registration upon the application of the Brass Growth Balance Method and the Bennett-Horiuchi Method. We also derive life tables based on the two methods and asses the effects of the major causes of death. The data used are from the deaths that occurred and were registered in the three districts in 1999 and the population enumerated in 1989 and 1999 censuses.

5.1 Estimation of Completeness of Death Registration

In this section we estimate the completeness of death registration by applying the Brass Growth Balance Method and the Bennett-Horiuchi method. We also compare the results from the two methods. The census figures correspond to 24, August, 1999 and the deaths are centred on 1, July, 1999 which gives difference in time of 55 days or 0.1506 of a year. Thus the adjustment factors are 1.007, 1.001 and 1.007 for Nairobi, Nyeri and Bungoma respectively. Since these adjustment factors are insignificant, no adjustment will be made on the census data for all the districts in estimating completeness of death registration.

5.1.1 Brass Growth Balance Method

The growth balance method was proposed by Brass in 1975 for the estimation of completeness of adult deaths. The technique is valuable for correcting the registered number of deaths and it is therefore an attempt to use the direct methods of estimation. The data required for this method are:

a) the number of deaths for a given period.

b) the population in each age group at the mid-point of the period being referred to.

The growth balance method examines the relationship between two sets of ratios for different ages of the population. The ratios are the population at a particular age, N(x), to the population above the same age, N(x+), and the ratios of deaths among those aged above a given age, D(+), to the population above the same age, N(x+). For a constant completeness in reporting for all ages, undistorted age structure of the population due to age misreporting, migration or fertility change, a graph of partial death rates against partial birth rates should yield a straight line.

Table 5.1 presents the population at exact age x, N(x), the population over age x, N(+), the deaths above age x, D(+), and the ratios generated for males in Bungoma. The partial birth rates are calculated as N(x)/N(x+) whereas the partial death rates are calculated as D(x+)/N(x+).

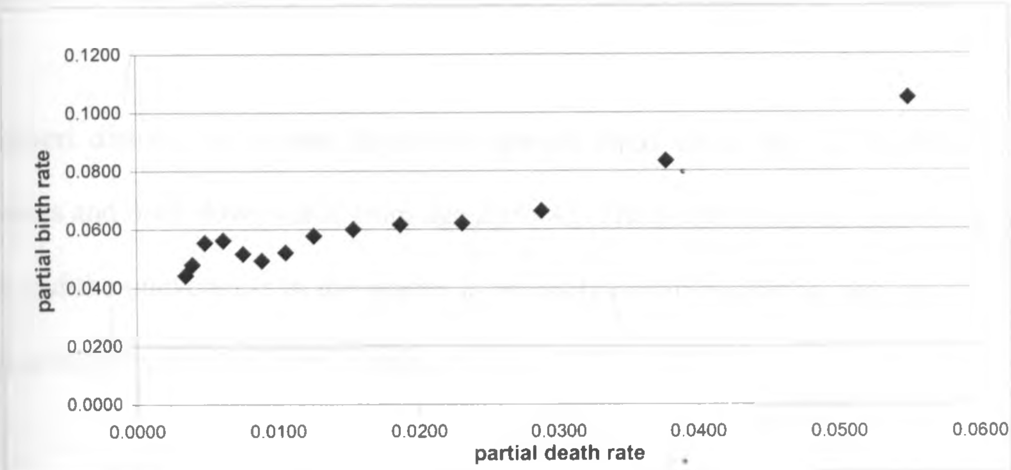
Table 5.1 Partial Rates Males Bungoma

Age	N(x)	N(x+)	D(x+)	Partial Death rate	Partial Birth rate
5	15123.4	341127	1198	0.0035	0.0443
10	13123.4	274053	1097	0.0040	0.0479
15	11644.3	209893	1030	0.0049	0.0555
20	8861.9	157610	979	0.0062	0.0562
25	6266.0	121274	924	0.0076	0.0517
30	4684.8	94950	851	0.0090	0.0493
35	3872.8	74426	794	0.0107	0.0520
40	3248.9	56222	714	0.0127	0.0578
45	2517.6	41937	652	0.0155	0.0600
50	1915.0	31046	588	0.0189	0.0617
55	1415.6	22787	534	0.0234	0.0621
60	1119.3	16890	493	0.0292	0.0663
65	967.1	11594	444	0.0383	0.0834
70	757.5	7219	402	0.0557	0.1049

Source: Computed from Death Registration and Population Census Data, 1999

An examination of figure 5.1 reveals that the points bend upwards at the younger ages and back downwards at ages 20 to 30 years. However, the points show an approximate linear relationship though the data is far from perfect. The pattern of distortions observed in the data are typical of those produced by the effects of migration, age misreporting, under-enumeration, differential completeness of death registration or lack of stability in the population.

Fig5.1: Partial birth/death rate for males in Bungoma



Source: Generated from death registration data, 1999 upon the application of Brass Growth Balance Method

The above process was repeated for both sexes in each of the study districts and the results are presented in appendix 2 (tables 2.1 to 2.5) and the corresponding graphical displays in figures 2.1 to 2.5. It is observed from the results that whereas the ratios for females in Bungoma and the males and females in Nyeri depict a fairly linear relationship, the ratios for the Nairobi data are erratic for both males and females. The ratios for males in Nairobi depict two distinct patterns with the first ten points forming a near straight line that bends upwards up to age 55 and the remaining points from age 60 form a roughly flat line. It is apparent that the migration patterns in Nairobi are reversed at age 55 for the males. This may be explained by the fact that most of those in formal employment retire at age 55 years.

For females in Nairobi, the unevenness in the graph resembles the graph for males. The points bend upward up to age 25 and back downwards from age 30. The points also depict two distinct patterns with the first six points forming a near straight line that bends upwards and the remaining points form a roughly flat line. As opposed to the males, the migration patterns among the females appear to change at age 30.

In Nyeri district, the points depict an upward trend up to age 15 for both males and females and back downwards from age 20 to 45. The points show an approximate straight line and the unevenness in the graphs is probably due to migration, age misstatement and changing mortality and fertility patterns.

Table 5.2 shows a summary of the computed values of k, c and r where k is the adjustment factor, c is the completeness of registration and r is the corresponding population growth rate. Two procedures were employed in the estimation of the adjustment factor, k, and hence the completeness of death registration for each of the sexes in the three districts. The 'grouped means' procedure was applied to the Bungoma data while the 'trimmed means' procedure was applied to the Nairobi and Nyeri data sets. The trimming procedure makes the fit less sensitive to large deviations from linearity at the extreme ends of the range.

The selected points for either of the procedures were divided into two equal groups. The observations for each of the groups were summed and then divided by the number of observations in each group (7) to get the mean value. In the application of the trimmed means procedure, different weights were applied to the extreme points. X1 and X2 are the mean values for the partial death rates for groups 1 and 2 respectively and Y1 and Y2 are the corresponding mean values for partial birth rates. The slope of the approximated straight line is calculated as

$$k=(Y2-Y1)/(X2-X1).$$

The completeness of death registration is therefore given as the reciprocal of k i.e. c=1/k and the corresponding value of 'r' is calculated as r=Y1-k*X1.

The completeness of death registration in Bungoma and Nyeri in 1999 with respect to the population enumerated was estimated at 105 and 127 percent for males and 76.2 and 94 percent for females respectively. This means that males were over registered by 5 and 27 percent while females were under registered by 23.8 and 6 percent in Bungoma and Nyeri respectively. The corresponding values of growth rates (r) were estimated to be 4.5 and 4.0 percent for males and 4.3 and 4.0 percent per annum for females in Bungoma and Nyeri districts respectively. The growth rates for Bungoma district were fairly close to those obtained from the census data while the growth rates for Nyeri district are about five times those estimated from the census data.

Completeness of death registration in Nairobi was estimated at 55.4 percent for males and 138 percent for females with respect to the 1999 population. This means that males were under registered by 44.6 percent while females were over registered by 38 percent.

Enforcement of the urban by-laws and other legal requirements may imply that death registration in urban areas would be expected to be almost complete for both the sexes. It is therefore likely that the levels of registration among males in Nairobi are under estimated.

Table 5.2 Summary of completeness of death registration

	Completeness		Adjustment Factor		Growth Rate	
District	Male	Female	Male	Female	Male	Female
Nairobi	0.554	1.38	1.804	0.73	0.035	0.06
Nyeri	1.27	0.94	0.79	1.07	0.04	0.04
Bungoma	1.05	0.762	0.954	1.313	0.045	0.043

Source: Generated from death registration data, 1999

The Growth Balance Method has limitations in estimating death registration completeness due to the underlying assumptions. First, the estimation of a single adjustment factor is subjective in the presence of distortions in the data. This is because when the resulting graph is uneven, making a decision on the completeness of death registration depends on the range of points chosen and the procedure used in fitting a straight line. Second, the effectiveness of the technique is limited by distortions caused by migration, if death registration is age-related and if age misstatement in the registered deaths or the living population is severe. Normally, irregularities in the graphs should be an indicator to the performance of the method. The results generated through this technique should therefore be treated with caution.

5.1.2 Bennett-Horiuchi Method

The Bennett-Horiuchi (Age-Specific Growth Rate) technique uses age specific population growth rates to estimate the completeness of death registration. The technique generates a series of N*(x) values which are also useful in analyzing the data under study for violations of the assumptions underlying the method. By cumulating N*(x) and N(x) values, we derive measures of completeness for both males and females in each of the study districts. The cumulating process tends to reduce the effects of age misstatement, differential enumeration and age dependent registration.

The Bennett-Horiuchi model is designed so that it attempts to reproduce the age distribution of the population from the distribution of the registered deaths. Based on the reproduced age distribution, a sequence of values of ${}_{10}N^*_{x-5}(x)/{}_{10}N_{x-5}(x)$ is obtained and a flat sequence which equals approximately one indicates complete death registration. Values below one indicates under registration and values above one indicates over registration.

After computing the age-specific rates of growth from the formula

${}_5r_x = 1/10(\ln ({}_5P_x(1999)/{}_5P_x(1989)))$, values of N(A), calculated for different 'truncation ages' (A=60,55,50) have been estimated by the alternative method

$N^*(A)=D(A+)\exp(r(A+)^*Z(A))$, where

$$z(A) =a(A)+b(A)+c(A)\exp(D(45+)/D(10+))$$

and r = r(A+) is the stable growth rate at age A and above, D(45+)/D(10+) is the ratio of the recorded deaths over age 45 to the recorded deaths over age 10 and a(A),b(A) and c(A) are coefficients (see Appendix1). ${}_5P_x(1989)$ and ${}_5P_x(1999)$ are the populations enumerated in 1989 and 1999 respectively in age group x to x+4. The truncation ages are varied so that the consistency of the data used to estimate death registration completeness can be assessed.

Estimates of death registration completeness are derived from the median of a series of ${}_{10}N^*{}_{x-5}(x)$ values divided by ${}_{10}N_{x-5}(x)$ values. Table 5.3 gives a summary of the results for all the truncation ages for both males and females in Bungoma. The median estimates for Bungoma district for males are 123, 118.5 and 122 percent for A=60, A=55 and A=50 respectively. The results imply that deaths among the males in Bungoma district were over registered by 23, 18.5 and 22 percent for A=60, A=55 and A=50 respectively. Completeness of death registration for females in Bungoma district indicates that females were under registered by 7 and 5.5 percent at truncation ages 50 and 55 years respectively. At truncation age 60 years, the results show that female registration was complete in Bungoma district.

Table 5.3 Summary of completeness of Death Registration - Bungoma

	Truncation Age (A) (Males)- Bungoma			Truncation Age (A) (Females)- Bungoma		
Age	60	55	50	60	55	50
0						
5	1.45	1.36	1.37	1.24	1.17	1.15
10	1.35	1.27	1.28	1.16	1.09	1.07
15	1.21	1.14	1.15	1.04	0.98	0.96
20	1.23	1.16	1.17	1.00	0.94	0.92
25	1.33	1.25	1.26	1.01	0.95	0.93
30	1.38	1.29	1.30	1.06	0.99	0.97
35	1.29	1.21	1.22	1.00	0.94	0.92
40	1.14	1.07	1.07	0.90	0.84	0.82
45	1.05	0.98	0.99	0.83	0.78	0.76
50	0.98	0.92		0.79	0.73	
55	0.99			0.78		
60+						
Median	123	118.5	122	100	94.5	93

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

$N(A) = D(A+)*\exp(r(A+)*Z(A))$.
$z(A) = a(A) + b(A)*r(a+) + c(A)*\exp(D(45+)/D(10+)$.

The estimation process was repeated for both males and females in Nairobi and Nyeri districts for each of the truncation ages A= 60, 55 & 50. Tables 3.1 to 3.18 in Appendix 3 shows the computation procedures. Tables 5.4 and 5.5 summarizes the results for all the 'truncation' ages for Nairobi and Nyeri districts respectively. The results indicate that for males in Nairobi, the median values computed are 64, 58.5 and 61 percent for truncation ages A=60, A=55 and A=50 respectively. This means that males in Nairobi were under registered by about 40 percent. In Nyeri district, males were under registered by about 44 percent. For females, Nairobi district over registered by about 30 percent whereas Nyeri district under registered by about 58 percent.

Table 5.4 Summary of completeness of Death Registration Nairobi

	Truncation Age (A) (Males)-Nairobi			Truncation Age (A) (Females)-Nairobi		
Age	60	55	50	60	55	50
0						
5	1.89	1.79	1.84	3.14	3.07	3.30
10	2.05	1.94	2.00	3.19	3.12	3.35
15	1.68	1.59	1.63	2.22	2.18	2.34
20	0.87	0.82	0.85	1.25	1.22	1.31
25	0.54	0.51	0.52	0.91	0.89	0.96
30	0.50	0.47	0.48	0.96	0.94	1.01
35	0.53	0.50	0.52	1.09	1.06	1.15
40	0.58	0.54	0.56	1.18	1.15	1.24
45	0.63	0.58	0.61	1.30	1.27	1.38
50	0.64	0.59		1.30	1.27	
55	0.76			1.42		
60+						
Median	64	58.5	61	130	124.5	131

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

$N(A) = D(A+)*\exp(r(A+)*z(A))$.

$z(A) = a(A) + b(A)*r(a+) + c(A)*\exp(D(45+)/D(10+)$.

Table 5.5 Summary of completeness of Death Registration Nyeri

	Truncation Age (A) (Males)-Nyeri			Truncation Age (A) (Females)-Nyeri		
Age	60	55	50	60	55	50
0						
5	0.44	0.43	0.44	0.36	0.35	0.35
10	0.43	0.43	0.44	0.35	0.34	0.34
15	0.42	0.42	0.43	0.34	0.34	0.34
20	0.49	0.48	0.49	0.39	0.38	0.38
25	0.57	0.56	0.58	0.43	0.42	0.42
30	0.59	0.59	0.60	0.44	0.43	0.43
35	0.56	0.55	0.57	0.42	0.41	0.41
40	0.59	0.58	0.60	0.44	0.43	0.43
45	0.67	0.66	0.68	0.50	0.49	0.49
50	0.59	0.58		0.47	0.45	
55	0.56			0.46		
60+						
Median	56	55.5	57	43	41.5	41

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

N(A) = D(A+)*exp(r(A+)*z(A)).
z(A) = a(A) + b(A)*r(a+) + c(A)*exp(D(45+)/D(10+).

A comparison of the completeness of death registration from the two methods (Table 5.6) shows that the results from the two methods for Nairobi are quite close for both males and females. The overall results indicate that males were under registered and females over registered in Nairobi upon the application of the two methods. However, the completeness values computed from the Brass method are lower than those computed from the Bennett-Horiuchi method in respect of males and higher in respect of females. The closeness of the results implies that migration may have had the same effects on the two methods as regards the Nairobi data.

For Nyeri district, the values estimated from the Brass Growth Balance method are about twice the values estimated from the Bennett-Horiuchi method. It is unlikely that the results derived from Bennett-Horiuchi method reflects the true levels of completeness of death registration. It is probable that some of the underlying assumptions of the Bennett-

Horiuchi method were violated for both males and females in Nyeri district. In Bungoma district, the values estimated from the Brass Growth Balance method are lower than the value estimated from the Bennett-Horiuchi method by about 17 percent for both sexes. For both the methods, males were over-registered .and females under-registered in Bungoma district.

Table 5.6 Summary of Completeness of Death Registration
From Brass's & Bennett-Horiuchi Methods

	Brass (%)		ASGR (%)	
District	Male	Female	Male	Female
Nairobi	55.4	138	61	130
Nyeri	127	94	56	41.5
Bungoma	105	76.2	122	94.5

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

The estimated values of completeness of death registration due to the Bennett-Horiuchi method for both males and females in Nyeri district and for males in Nairobi district may be an under estimation. The under estimation may be attributed to limitations in the Bennett-Horiuchi model. These limitations include:

First, the two districts may have experienced significant rates of migration in the intercensal period and this may have biased the age specific growth rates. Net out-migration biases the completeness upward and net in-migration downward. As alluded to earlier in chapter 4, Nairobi experienced significant migration, particularly among males. In the absence of any adjustments to the data, the estimates may be biased. However, other factors, other than migration may have contributed to the under estimation in Nyeri district.

Second, the assumption of age 50 as the age above which all misstatement occurs may not be realistic for the districts under study. Data evaluation of past censuses and sample surveys has shown that age misstatement in the Kenyan data is a phenomenon that affects both males and females at all ages. Indices calculated to this effect illustrate the degree of age misreporting in the 1999 population census, which therefore implies violation of the assumption. The Myers, Bachi's and Whipples indices in 1999 at the national level were estimated at combined levels of 1.5, 10.2 and 14.7 percent respectively (CBS, 1999).

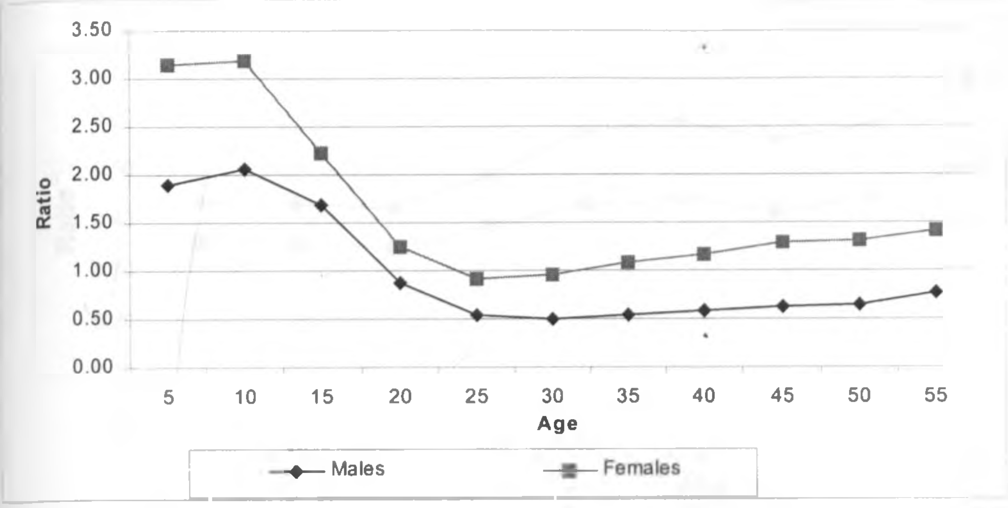
Third, the current method is based on the assumption that levels of completeness of death registration are independent of age among adults. However, completeness of death registration may differ by age and between sexes. The social status, which is determined by age in some societies, is a factor that may determine the completeness of registration in a population. Furthermore, due to cultural factors, males are more likely to be registered than females, particularly in rural areas.

Fourth, the technique is sensitive to differential enumeration of two successive censuses. Differential enumeration has an effect on the age-specific growth rates and may bias the results of death registration upward or downward. .When the first census is under enumerated than the second census, then the age specific growth rates will be biased upwards and this leads to over estimation of death registration completeness. If the second census is under enumerated than the first census, then age specific growth rates may be biased downward and the associated completeness of death registration is under estimated. If there was differential enumeration in the 1989 and 1999 censuses, then this may have affected the computed completeness of death registration in each of the study districts. At the national level, the estimated levels of under coverage were 6.0 and 2.7 percent in 1989 and 1999 respectively, (CBS, 1999). Assuming that the same levels were applicable at the district levels, then it implies that there was differential enumeration of the censuses in the two censuses.

In this study we are not estimating the extent to which the above factors may have contributed to biased results. However, it is strongly suggested that net in-migration was the major factor in the downward bias among males in Nairobi. From the 1989 and 1999 census results, Nyeri district had an intercensal growth rate of 0.8 percent per annum. As much as it is acceptable that Nyeri district may have experienced drastic changes in demographic indicators, it is also important to appreciate the fact that changes in the population are gradual. The strong suggestion here is that the age specific growth rates were grossly under estimated and led to under estimated completeness of death registration. It is therefore possible that under enumeration of the population in 1999 or over enumeration in the 1989 census may be the major factor in the low levels of completeness of death registration in Nyeri district.

Figure 5.2 shows the characteristics of the sequence of ratios for each of the sexes in Nairobi district. With no distortions in the data, the graphs would present a straight line. The results show that the computed ratios among females in Nairobi were higher than the corresponding ratios among males. The sequence of ratios for Nairobi depicts a decreasing trend from age 5 to age 20 and then stabilize for both sexes as age advances. The erratic nature of the sequence may probably be because of undercounts in the younger ages or over counts in the ages above 20 years..

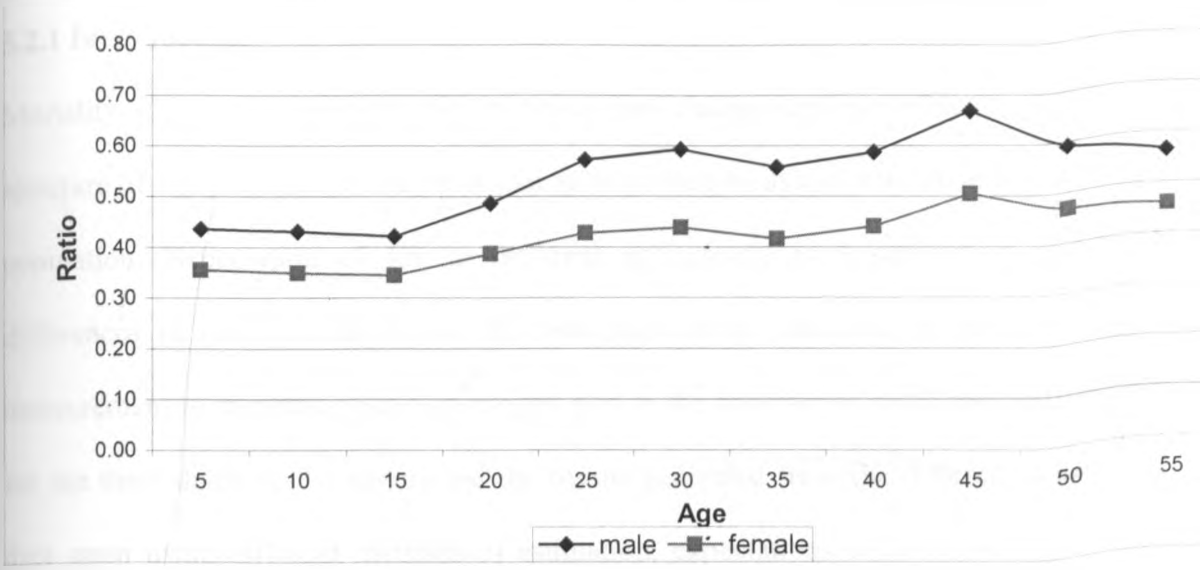
Fig.5.2: Completeness of Death Registration in Nairobi Based on Bennett-Horiuchi Method



Source: Generated from death registration data, 1999 and Population Census 1989 and 1999 upon the application of the Bennett-Horiuchi Method

In Nyeri district, the graphs present increasing sequences of ratios for both sexes. The graphs are elevated at ages between 15 and 45 years, which may be attributed to emigration at these age groups. The ratios at ages 5 to 15 years are lower than the ratios at the older ages probably due to under enumeration or age misstatement. Drastic reductions in fertility levels are also possible reasons for this phenomenon.

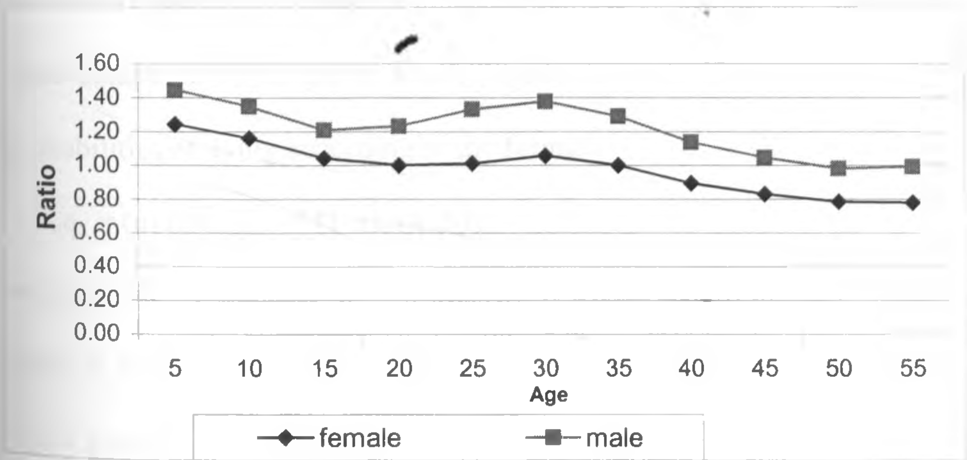
Fig.5.3: Completeness of Death Registration in Nyeri Based on Bennett-Horiuchi Method



Source: Generated from death registration data, 1999 and Population Census, 1989 and 1999 upon the application of Bennett -Horiuchi Method

Figure 5.4 depicts the ratios in Bungoma district. The graphs present a decreasing sequence of ratios with an elevation at ages 25 to 35 possibly due to emigration at these age groups. The ratios for males are higher than the ratios for females which implies higher registration among males than females.

Fig.5.4: Completeness of Death Registration in Bungoma Based on Bennett-Horiuchi Method



Source: Generated from death registration data, 1999 and Population Census, 1989 and 1999 upon the application of Bennett-Horiuchi Method

5.2 Life Table Construction

5.2.1 Introduction

Mortality plays an important role in population change and in influencing the age structure of a population. Mortality is also an important measure of the Health Status of a population. Expectation of life at different age groups is a satisfactory index of differences in mortality levels for different populations. Because of these, mortality measurement in this study plays an integral part in the analyses of death registration data for the three districts. To understand the results generated from the different sources of data upon using different methods of estimation, expectations of life at all ages were calculated for each sex in the study districts.

5.2.2 Brass Growth Balance Method

For the Brass Growth Balance Method, the values generated for the completeness of death registration are used to correct the number of deaths registered for each of the sexes. The adjusted number of deaths at each age is given as ${}_5D_x/c$, or $k*{}_5D_x$ where ${}_5D_x$ is the number of registered deaths and k is the adjustment factor and c is the completeness of death registration. From the adjusted number of deaths, age-specific death rates (${}_nM_x$) were computed for a given sex for age x to x+4. The ${}_nM_x$'s were then converted to probabilities of dying according to the formula:

$${}_nq_x = (n)({}_nM_X)/(1 + (1\text{-}a)(n)({}_nM_X))$$

where 'a' is the fraction that an individual would live in the age interval. 'a' is normally taken to be 0.5 for ages above 4 years. For 0-1 years and 1-4 years 'a' is taken to be 0.1 and 0.4 respectively (Chiang, 1984).

For the open-ended interval the following relationship was applied:

$L_{75+} = l_{75+} \log_{10}(l_{75+})$.

This is due to the fact that the alternative formula which is given as

$L_{75+} = d_{75+} / M_{75+}$ tended to give, in most cases, extremely large values.

The Brass Growth Balance method is meant to estimate adult mortality. In this study ${}_5q_0$'s derived from the 1999 census were spliced with the ${}_5q_x$'s from the death registration data to generate complete life tables.

Table 5.7 shows the results of the life table for males in Bungoma district generated upon the application of Brass Growth Balance method. The life expectancies shows a decreasing trend from childhood to old age with the exception of the values at 0-4, which are lower than the life expectancy at age 5-9. The above process was repeated for females in Bungoma and for both sexes in Nairobi and Nyeri districts. The results of this process are presented in appendix 4.

Table 5.7 Life Table Bungoma Males from the application of Brass Method

Age	Recorded Pop. Males	$_5D_x$	Adjusted $_nD^*_x$	$_nM^*_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	84160	579	579		0.1090	0.8910	1000	4727.5	62960.7	63.0
5	67074	100	95	0.0014	0.0071	0.9929	891	4439.2	58233.2	65.4
10	64160	66	63	0.0010	0.0049	0.9951	885	4412.6	53793.9	60.8
15	52283	50	48	0.0009	0.0046	0.9954	880	4391.7	49381.3	56.1
20	36336	55	52	0.0014	0.0072	0.9928	876	4366.0	44989.6	51.3
25	26324	72	69	0.0026	0.0130	0.9870	870	4322.0	40623.6	46.7
30	20524	57	54	0.0027	0.0132	0.9868	859	4265.5	36301.6	42.3
35	18204	79	75	0.0041	0.0205	0.9795	847	4193.9	32036.1	37.8
40	14285	62	59	0.0041	0.0205	0.9795	830	4107.9	27842.2	33.5
45	10891	64	61	0.0056	0.0276	0.9724	813	4009.2	23734.3	29.2
50	8259	54	52	0.0062	0.0307	0.9693	791	3892.3	19725.1	24.9
55	5897	40	38	0.0065	0.0318	0.9682	766	3770.6	15832.9	20.7
60	5296	49	47	0.0088	0.0432	0.9568	742	3629.4	12062.3	16.3
65	4375	41	39	0.0089	0.0437	0.9563	710	3471.7	8432.9	11.9
70	3200	64	61	0.0191	0.0911	0.9089	679	3239.5	4961.1	7.3
75+	4019	333	318	0.0791	0.3301	0.6699	617	1721.6	1721.6	2.8

Source: Computed from Death Registration data, 1999 & Population Census, 1999

5.2.3 Bennett-Horiuchi Method

The Bennett-Horiuchi (Age-Specific Growth Rate) technique uses age specific population growth rates derived from consecutive censuses to generate life tables from incomplete death registration data. The technique does not depend on the use of model life tables except for the open-ended interval and it facilitates the construction of life tables which are corrected for both the under enumeration of the population and the under registration of deaths. In this technique, the death registration completeness is not required.

Table 5.8 shows the procedure of estimating the life expectancy at the open-ended interval (75+). The summation of values in column nine and the subsequent division of the values gives a ratio of 0.48 and a corresponding life expectancy of 9.31. Table 5.9 shows the results of the life table estimates of life expectancies for males in Bungoma district generated upon the application of the Bennett-Horiuchi Method. Tables 4.1 to

4.15 are the results for Nairobi and Nyeri districts for both sexes and for females in Bungoma district (see Appendix 4). In all the life tables, the life expectancies decreases with age as would be expected except for the first age group whose life expectancy is lower than the next age group. The life expectancy estimates from the application of the two methods may be considered as the lower and upper bounds within which the true value lies.

Table 5.8 Estimation of e(75) Bungoma Males Bennett-Horiuchi

Age	Male-89	Male-99	$_5r_x$	$\sum_5r_x$	2.5*($_5r_x$)	Exp (5*$\sum_5r_x$ +2.5*($_5r_x$))	$_5D_x$	c*B*$_5d_x$	N(x)
0	56743	84160	0.0394				579		30593
5	46468	67074	0.0367	0.0394	0.0918	1.3	100	133	24596
10	39550	64160	0.0484	0.0761	0.1210	1.7	66	109	20381
15	31998	52283	0.0491	0.1245	0.1227	2.1	50	105	15943
20	20693	36336	0.0563	0.1736	0.1408	2.7	55	151	12428
25	16388	26324	0.0474	0.2299	0.1185	3.6	72	256	9331
30	13180	20524	0.0443	0.2773	0.1107	4.5	57	255	7298
35	9603	18204	0.0640	0.3216	0.1599	5.9	79	463	5798
40	7716	14285	0.0616	0.3855	0.1540	8.0	62	497	4144
45	5590	10891	0.0667	0.4471	0.1667	11.0	64	707	2992
50	5037	8259	0.0494	0.5138	0.1236	14.8	54	798	2089
55	4282	5897	0.0320	0.5633	0.0800	18.1	40	724	1584
60	3336	5296	0.0462	0.5953	0.1155	22.0	49	1079	1313
65	2393	4375	0.0603	0.6415	0.1508	28.7	41	1178	998
70	1756	3200	0.0600	0.7018	0.1500	38.8	64	2485	703
75+	2754	4019	0.0378	0.7618	0.0945	49.6	333	16513	466
30d10	1836								
20d40	3805								
30d10/10d40	0.48	e(75)=9.3							
N(75)	465.75								

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

Table 5.9 Life Table Bungoma Males Bennett-Horiuchi method

Age	$_np_x$	$_nq_x$	$_nd_x$	L_x	$_5L_x$	T_x	e_x
0	0.8910	0.1090	109	1000	4728	68012	68.0
5	0.9955	0.0045	4	891	4445	63284	71.0
10	0.9963	0.0037	3	887	4427	58839	66.3
15	0.9965	0.0035	3	884	4411	54412	61.6
20	0.9949	0.0051	4	881	4392	50001	56.8
25	0.9913	0.0087	8	876	4362	45609	52.1
30	0.9913	0.0087	8	869	4324	41247	47.5
35	0.9840	0.0160	14	861	4270	36923	42.9
40	0.9825	0.0175	15	847	4199	32653	38.5
45	0.9747	0.0253	21	832	4110	28454	34.2
50	0.9708	0.0292	24	811	3998	24344	30.0
55	0.9726	0.0274	22	788	3884	20346	25.8
60	0.9581	0.0419	32	766	3750	16462	21.5
65	0.9522	0.0478	35	734	3582	12712	17.3
70	0.8942	0.1058	74	699	3310	9129	13.1
75+	0.0000	1.0000	625	625	5819	5819	9.3

Source: Computed from Death Registration data 1999 & Population Census, 1989&1999

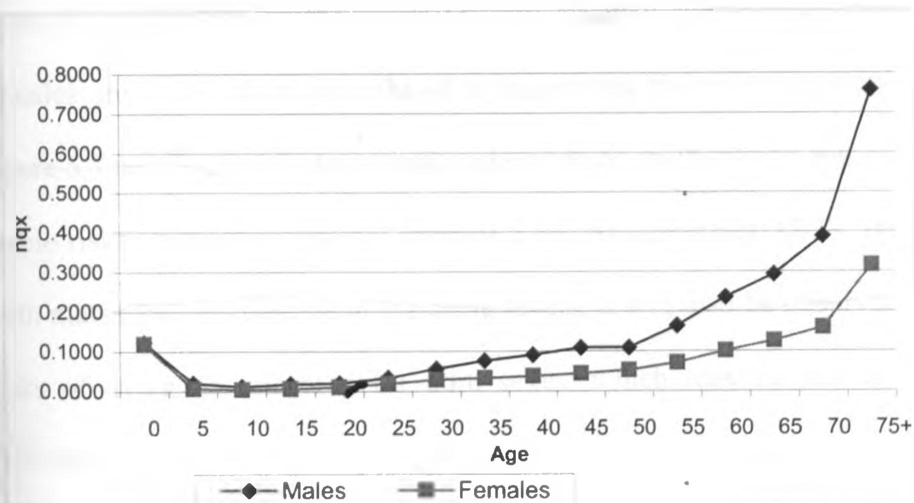
5.2.4 Comparison of Life Tables Derived from the Brass Growth Balance Method and the Bennett-Horiuchi Method

The two methods applied in this study are basically meant to estimate adult mortality levels from civil registration data. Whereas the Brass Growth Balance Method estimates e(o) as 63 years among males (table 5.7) in Bungoma district, the Bennett-Horiuchi method estimates the same as 68 years (table 5.9), a difference of 5 years. At all the age groups, the difference between life expectancies derived from the two methods are between 5 and 7 years with the highest difference observed at old age and this is probably due to the different procedures applied at this age.

In figures 5.5 and 5.6, the risks of dying are about the same for both males and females from childhood ages to age 15 with the males experiencing slightly higher risks of death. For both sexes, the risks of dying stabilize between ages 5 and 15 as displayed in both figures though the stability is extended to age 25 in figure 5.5.

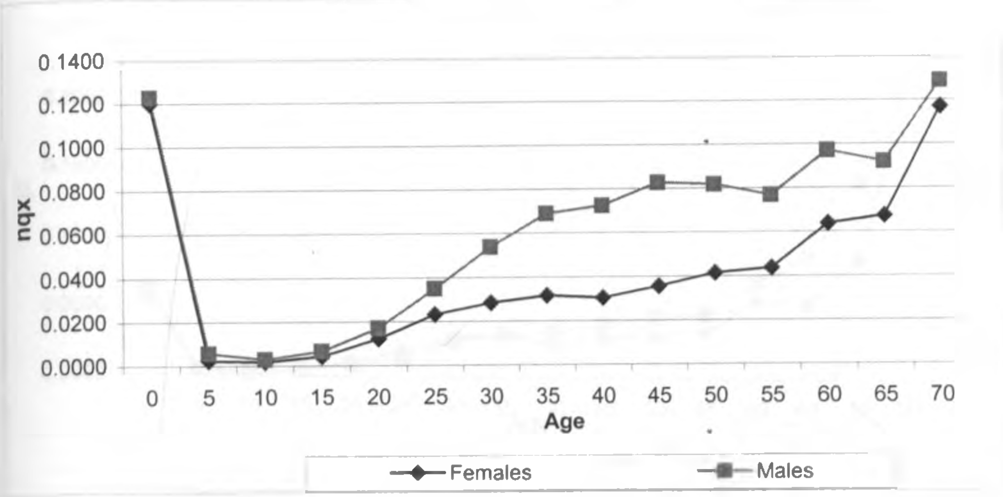
In figure 5.6, above age 20 the differences in the risks of dying between males and females widen and reach its peak at age 45, with males having a higher risk of dying. Above age 15 years, the risks of dying increases rapidly under the Bennett-Horiuchi method than for the Brass Growth Balance Method. Whereas the risks of dying shows a gradual increment and a widening gap between the sexes, the graph due to the Bennett-Horiuchi method shows drastic increases and larger differences between males and females above age 20. Between ages 15 and 55 the slopes of the graphs in figure 5.6 are steeper than those in figure 5.5. Between ages 30 and 50 figure 5.6 shows a bulge in the risks of dying among the males, which is an indication of higher mortality among males than females probably due to the effects of AIDS.

Fig.5.5: Mortality Levels in Nairobi Based on Brass Method



Source: Generated from death registration data, 1999 upon the application of Brass Growth Balance Method.

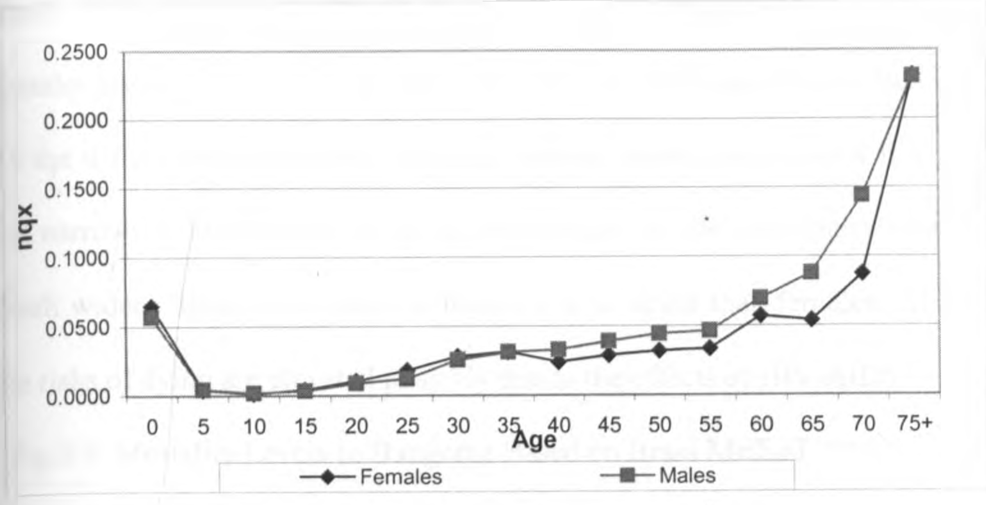
Fig.5.6: Mortality Levels in Nairobi Based on Bennett-Horiuchi Method



Source: Generated from death registration data, 1999 upon the application of Bennett-Horiuchi Method.

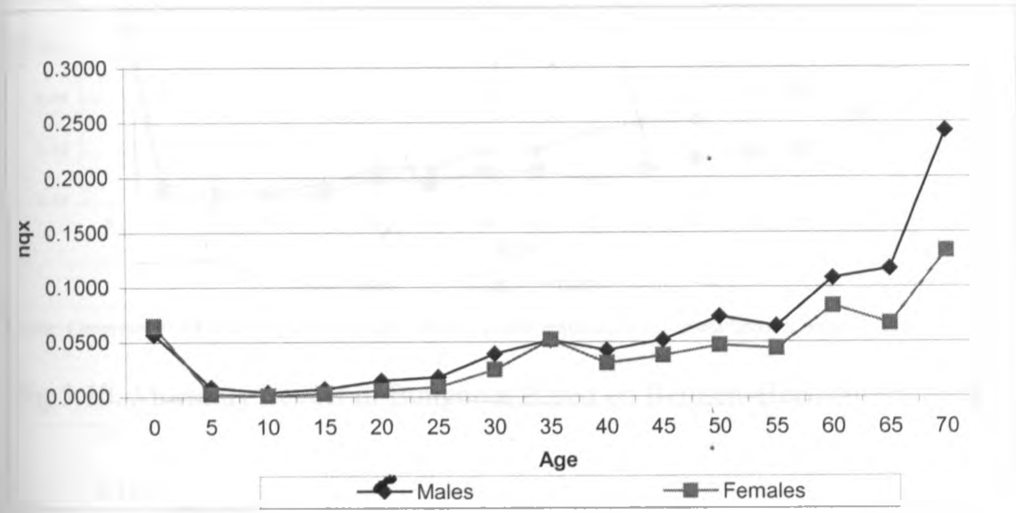
Figures 5.7 and 5.8 displays the risks of dying in Nyeri district. In figure 5.7, generated upon the application of the Brass Growth Balance Method, the risks of dying among females are higher than the risks of dying among males between ages 20 and 30. Both figure 5.7 and figure 5.8 shows high risks of death in childhood and old age and relatively stable risks of death in the age interval 5-15. At age group 35-39, the risks of death for both males and females are at the same levels. It will also be observed that at age 35, the risks of dying are elevated for both sexes, which may be due to the prevalence of HIV/AIDS.

Fig.5.7: Mortality Levels in Nyeri Based on Brass Method



Source: Generated from death registration data, 1999 upon the application of Brass Growth Balance Method.

Fig.5.8: Mortality Levels in Nyeri Based on Bennett-Horiuchi Method

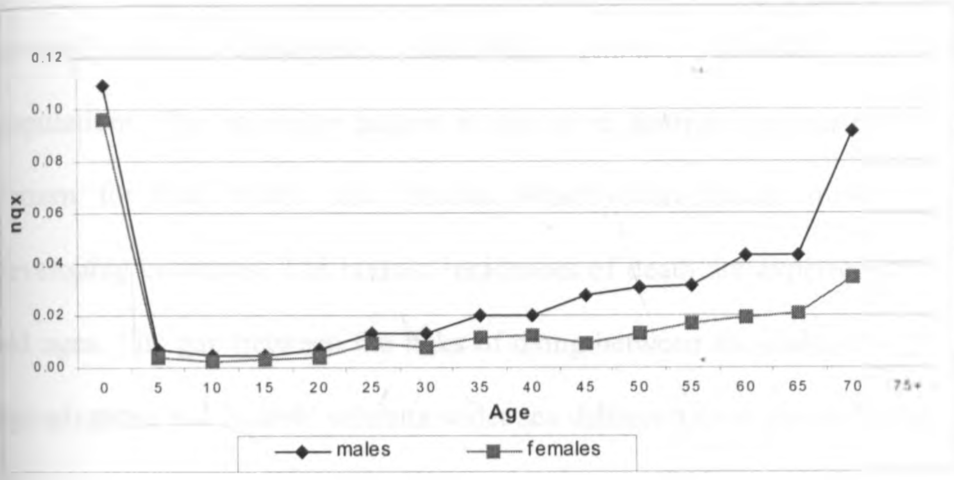


Source: Generated from death registration data, 1999 upon the application of Bennett-Horiuchi Method.

The display of figures 5.9 and 5.10 for Bungoma district shows markedly high differences in the risks of death. Figure 5.9, derived from the Brass Growth Balance Method, shows males are at higher risks of dying than females above age 5 and the difference between the risks of dying between the two sexes widens gradually with the highest differences experienced in old age.

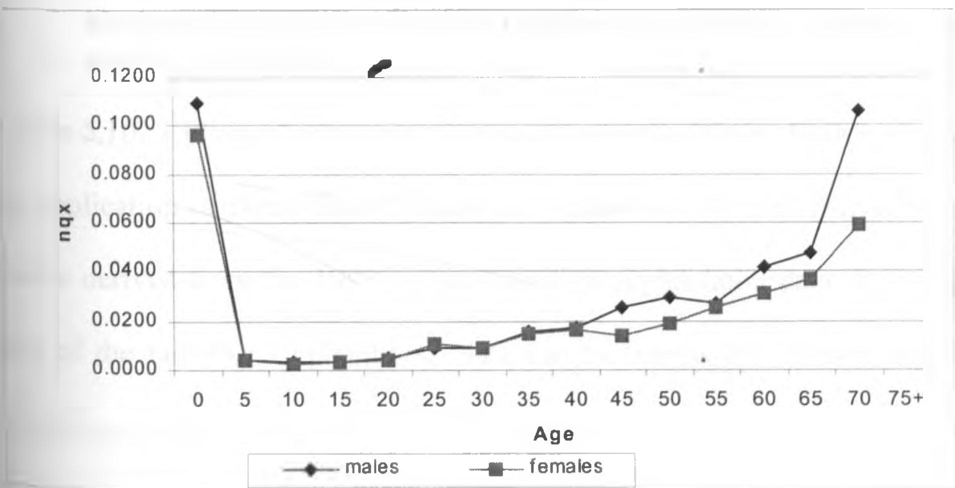
Figure 5.10, derived from the Bennett-Horiuchi Method, shows males at higher risk of death than females in childhood. From age 5 to 40, the risks of death between males and females are similar with slight differences at ages 25-30 and 35-40. Between ages 40 and 55 the difference in the risks of dying between males and females is significantly wide but narrows to almost zero at age 55. Above age 55, the differences between the risks of death widens again with males at higher risk of death than females. At ages 25 and 35, the risks of dying are elevated possibly due to the effects of HIV/AIDS.

Fig.5.9: Mortality Levels in Bungoma Based on Brass Method



Source: Generated from death registration data, 1999 upon the application of Brass Growth Balance Method.

Fig.5.10: Mortality Levels in Bungoma Based on Bennett-Horiuchi Method



Source: Generated from death registration data, 1999 upon the application of Bennett-Horiuchi Method.

It is therefore evident from the graphs that the age pattern of mortality varies substantially with age and sex with males experiencing higher risks of death than females. The incidence of mortality is high at the younger ages and stabilizes in the age intervals 5 to 15 before experiencing a rapid rise as age advances for both the Brass Growth Balance method and the Bennett-Horiuchi method. The mortality patterns in each of the district depict a rapid rise from age 25 particularly among the male population.

Irrespective of the methodology used, the results show that the risks of dying are generally higher among the males than females, a pattern experienced in most populations. The mortality pattern in the three districts demonstrates a near U-shaped pattern for both males and females, which characterizes most populations in the developing countries. The highest incidences of death are experienced in childhood and old ages. The gap between the risks of dying between the males and females widens as age advances and Nairobi exhibits wider sex differentials in the middle ages.

5.3 Comparison of Life Expectancies Generated from Brass Growth Balance Method, The Bennett-Horiuchi Method and Census results (Child Survival and Orphan hood).

Tables 5.10, 5.11 and 5.12 shows the results generated from death registration data upon the application of Brass Growth Balance Method and Bennett-Horiuchi Method and the results derived from the 1999 census based on orphanhood data. It is important to take note of the fact that 'orphanhood' data can be biased due to over-reporting or under-reporting of adult mortality. The estimates derived from the orphanhood data do not refer to the entire population since they reflect mortality experiences of parents with surviving children and the questions on orphanhood are asked of the entire population. Parents with several surviving children would tend to be over-reported. The survivorship estimates derived from these data do not refer to specific time periods and this is unlike estimates derived from death registration data, which refers to a specific period. Differences between the estimated life expectancies may therefore be due to differences in the time period the estimates refer to or due to differences in the methodologies applied.

Table 5.10 shows the estimated life expectancies upon the application of different methodologies and data sets for males and females for Nairobi district. Among the males, the Bennett-Horiuchi method over-estimates the life expectancies at all the ages while the Brass Growth Balance method under-estimates the life expectancies at ages 5 to 55 and over-estimates at age 60 and above. The absolute deviations from the census results upon the application of the two techniques are similar at ages 5 to 35. Above 35 years the deviations upon the application of the Bennett-Horiuchi method are higher than for the Growth Balance Method up to age 65. For females, the Brass Growth Balance method under-estimates the life expectancies at all the ages while the Bennett-Horiuchi technique over-estimates at all the ages. The estimates from the Brass Growth Balance method are generally closer to the census results than the Bennett-Horiuchi estimates for both sexes. The life expectancies obtained from the Bennett-Horiuchi technique are extremely high for females and deviates from the census results by between 21 and 43 percent.

Table 5.10 Comparison of life Expectancies -Nairobi

	Males					Females				
Age	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c
0	50.1	55.9	54.1	0.93	1.03	55.5	80.9	59.8	0.93	1.35
5	51.7	58.3	54.6	0.95	1.07	57.7	86.6	60.6	0.95	1.43
10	47.8	53.7	50.7	0.94	1.06	53.0	71.6	56.5	0.94	1.27
15	43.3	48.8	46.2	0.94	1.06	48.3	66.6	51.9	0.93	1.28
20	39.1	44.1	41.8	0.94	1.06	43.8	61.8	47.4	0.92	1.30
25	34.8	39.8	37.7	0.92	1.06	39.7	57.2	43.5	0.91	1.32
30	31.0	36.2	33.8	0.92	1.07	35.8	52.8	39.8	0.90	1.33
35	27.7	33.1	30.2	0.92	1.10	31.9	48.1	36.1	0.88	1.33
40	24.8	30.4	26.9	0.92	1.13	28.0	43.2	32.4	0.87	1.33
45	22.0	27.6	23.5	0.94	1.17	24.2	38.2	28.7	0.84	1.33
50	19.4	24.8	20.2	0.96	1.23	20.4	33.4	24.9	0.82	1.34
55	16.5	21.8	16.9	0.97	1.29	16.8	28.5	21.0	0.80	1.36
60	14.2	18.4	13.8	1.03	1.34	13.4	23.6	17.3	0.78	1.36
65	12.8	15.1	10.9	1.18	1.39	10.0	19.0	13.8	0.72	1.38
70	12.1	11.4	8.3	1.46	1.38	6.4	14.1	10.7	0.60	1.31
75+	13.3	7.8	6.2	2.14	1.25	3.2	9.7	7.9	0.41	1.22

Source: Computed from Death Registration data, 1999 & Population Census, 1999

Table 5.11 shows the results in Nyeri district. The Brass Growth Balance Method over-estimates the life expectancies for males by between 11 percent and 15 percent at most of the ages but at 65 it over-estimates by 4 percent. The Bennett-Horiuchi method over-estimates the life expectancies for males by 2 percent at birth and by 3 percent at ages 5 to 30, over-estimates by 5 percent at age 35 and by 7 and 8 percent at ages 40 and 45 respectively. Between ages 50 and 70, the values are over-estimated by between 10 and 16 percent.

For females, the Brass Growth Balance method under-estimates the life expectancies by 1, 2, 3, 4 and 5 percent at ages 5 to 10, 15 to 20, 25, 30 to 35 and 40 respectively. Above age 50, the life expectancies are over-estimated by over 8 percent. The Bennett-Horiuchi technique over-estimates the life expectancies by 1 percent at ages 5 to 20 and under-estimates the life expectancies by 2 percent at ages 25 to 35 and then over-estimates by 2 percent at ages 40 and 45. Finally, the Bennett-Horiuchi Method over-estimates the life expectancies by 4, 7, 8 and 14 percent at ages 50, 55, 60 and 65 respectively. The results obtained upon the application of the Bennett-Horiuchi technique are reasonably close to the census results as compared to the Brass Growth Balance Method for both sexes. The life expectancy at birth estimated from the Bennett-Horiuchi method equals the value derived from the census data.

Table 5.11 Comparison of Life Expectancies-Nyeri

	Males					Females				
Age	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c
0	66.4	61.6	60.2	1.10	1.02	66.4	67.7	67.7	0.98	1.00
5	65.3	60.2	58.5	1.12	1.03	65.8	67.3	66.3	0.99	1.01
10	60.5	55.7	54.3	1.11	1.03	61.0	62.4	61.9	0.99	1.01
15	55.6	50.9	49.6	1.12	1.03	56.1	57.5	57.1	0.98	1.01
20	50.7	46.3	45.0	1.13	1.03	51.3	52.6	52.3	0.98	1.01
25	46.0	41.9	40.6	1.13	1.03	46.7	47.9	48.2	0.97	0.99
30	41.4	37.6	36.4	1.14	1.03	42.3	43.3	44.0	0.96	0.98
35	37.2	34.0	32.5	1.14	1.05	38.2	39.4	39.9	0.96	0.99
40	33.0	30.8	28.7	1.15	1.07	34.1	36.4	35.8	0.95	1.02
45	28.7	27.0	25.0	1.15	1.08	29.7	32.4	31.7	0.94	1.02
50	24.5	23.4	21.3	1.15	1.10	25.3	28.6	27.5	0.92	1.04
55	20.3	20.0	17.7	1.14	1.13	20.9	24.9	23.3	0.90	1.07
60	15.9	16.2	14.3	1.11	1.13	16.4	20.9	19.3	0.85	1.08
65	11.6	12.9	11.1	1.04	1.16	12.0	17.6	15.4	0.78	1.14
70	7.2	9.3	8.3	0.87	1.11	7.5	13.6	11.8	0.63	1.16
75+	2.8	6.4	6.1	0.46	1.05	2.8	10.3	8.7	0.33	1.19

Source: Computed from Death Registration data, 1999 & Population Census, 1999

Table 5.12 shows the results in Bungoma district. For males, the Brass Growth Balance Method over-estimates the life expectancies at ages 5 to 50 by between 3 and 11 percent and at age 55 the values estimated from the Brass and the census results are similar. The Bennett-Horiuchi technique over-estimates the life expectancies by between 21 and 26 percent between ages 5 and 70.

For females, the Brass Growth Balance Method over-estimates the life expectancies at ages 5 to 25 by between 1 and 4 percent and under-estimates at ages 30 to 45 by between 1 and 8 percent. The life expectancies above age 50 are over-estimated by over 11 percent. The Bennett-Horiuchi method over-estimates the life expectancies by between 3 and 10 percent at ages 5 to 65 and under-estimates by 1 and 10 percent at ages 70 and 75 respectively.

Table 5.12 Comparison of Life Expectancies-Bungoma

	Males					**Females**				
Age	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c	Brass a	Bennett-Horiuchi b	Census c	a/c	b/c
0	62.8	68.0	54.3	1.16	1.25	67.2	70,8	61.5	1.09	1.15
5	65.1	71.0	58.6	1.11	1.21	69.0	73.1	66.5	1.04	1.10
10	60.6	66.3	54.9	1.10	1.21	64.3	68.4	62.5	1.03	1.09
15	55.9	61.6	50.4	1.11	1.22	59.4	63.5	57.8	1.03	1.10
20	51.1	56.8	46.1	1.11	1.23	54.6	58.8	53.4	1.02	1.10
25	46.5	52.1	42.0	1.11	1.24	49.8	54.0	49.4	1.01	1.09
30	42.1	47.5	38.2	1.10	1.24	45.2	49.6	45.7	0.99	1.08
35	37.6	42.9	34.6	1.09	1.24	40.5	45.0	41.9	0.97	1.07
40	33.4	38.5	31.1	1.07	1.24	36.0	40.6	38.0	0.95	1.07
45	29.1	34.2	27.7	1.05	1.23	31.3	36:3	34.0	0.92	1.07
50	24.9	30.0	24.1	1.03	1.24	26.6	31.8	30.0	0.89	1.06
55	20.6	25.8	20.6	1.00	1.25	21.9	27.3	25.9	0.85	1.05
60	16.2	21.5	17.1	0.95	1.26	17.2	23.0	21.9	0.79	1.05
65	11.8	17.3	13.8	0.86	1.25	12.5	18.6	18.0	0.69	1.03
70	7.3	13.1	10.8	0.67	1.21	7.7	14.3	14.4	0.54	0.99
75+	2.8	9.3	8.2	0.34	1.14	2.9	10.0	11.1	0.26	0.90

Source: Computed from Death Registration data, 1999 & Population Census, 1999

The ratios calculated in the above tables shows that the results derived from the two methods vary by sex and age in each of the districts. It is observed that the Brass Growth Balance method generally under estimates the life expectancies whereas the Bennett-Horiuchi method over estimates at most of the ages. Since we don't know the true values, we are relying on the census estimates as the benchmark, which may be biased.

In Nairobi, we recommend the use of the Bennett-Horiuchi method for both males and females in estimating the completeness of death registration since the basis of the Brass Growth Balance method is based on the linearity of the graphs displayed. The graphs were found to be curvilinear for both sexes which signals that the technique performed poorly and thus the results would be unreliable. In deriving the life tables, the death registration completeness computed from the Bennett-Horiuchi method should then be used to adjust the data. The direct use of the Bennett-Horiuchi model in deriving the life tables don't give consistent results with the census results. However, the nature of the data in Nairobi may require the application of more refined models to accommodate the high rates of migration.

In Nyeri, we recommend the use of the Brass Growth Balance method for the estimation of death registration completeness due to the evenness in the graphs displayed and the completeness of death registration results are plausible as compared to those generated from the Bennett-Horiuchi method. However, to estimate life expectancy, it is recommended that the Bennett-Horiuchi model should be used since it gives more consistent results than the Brass Growth Balance method.

In Bungoma district, estimation of the completeness of death registration from the Brass Growth Balance method would be preferred in this study because of the evenness of the ratios. The population growth rates for both males and females derived from the model are also consistent with the growth rates derived from the census results, which is reassuring. For the derivation of life tables, in this study we would prefer the Brass Growth Balance method for males and the Bennett-Horiuchi method for females. This is because the life expectancy derived from the Brass Growth Balance method for males are more consistent with the census results while the Bennett-Horiuchi method gives more consistent results for females.

5.4 Effects of Specific Causes of Death on Mortality in the Study Districts

Diseases such as smallpox, plaque, malnutrition and sleeping sickness plagued the African continent in the early 1900's and some of these diseases have been eliminated through public health programmes and provision of health services (Kucynski, 1949). In developed countries, infectious diseases have been eliminated and it is possible that some of the diseases still plaguing the Kenyan population may eventually be eliminated.

Cause elimination therefore assesses the 'effects of elimination of any single disease on the duration of life'. This study is therefore interested in assessing the effect on survival probability of 'removing' one cause of death. To do this, we assume that the various causes act independently of each other and their respective forces of mortality are additive i.e.

$$\mu (x) = \mu_\alpha (x) + \mu_{(-\alpha)} (x)$$

where $\mu_\alpha (x)$ is the force of mortality due to cause C_α and $\mu_{(-\alpha)} (x)$ is the force of mortality due to all other causes combined.

If the survival probability when, C_α is the only effective cause of death, is $l_\alpha*(x)$ we have the additivity assumed above of the forces of mortality translating to

$$l_\alpha = l_\alpha*(x)* l*_{(-\alpha)} (x)$$

On the application of the relationship between survival function and force of mortality, we have

$$(l_\alpha^*(x+n)/ l_\alpha^*(x)) = [l(x+n)/l(x)]^R$$

Once the ordinary life tables from all causes combined have been generated, we raise its survivorship to the powers represented by R's.

R can be estimated by the corresponding age-specific death rates (Chiang, 1968) i.e.

${}_nM_{x,\alpha}/ {}_nM_{x,+}$

Tables 5.13, 5.14 and 5.15 presents the effects on elimination of single causes of death for both males and females in the three districts. The results indicate that effects of elimination are more pronounced at the younger ages than at the old ages for all the diseases in all the districts. The effects of eliminating one of the diseases decreases with age so that as age advances the extra number of years on the life expectancy decreases. The effects of elimination vary with gender and the prominence of the disease in the population.

5.4.1 Effects of Specific Causes of Death on Mortality in Nairobi

Pneumonia, HIV/AIDS, tuberculosis and malaria were the four leading specific causes of death in Nairobi in 1999. Table 5.13 illustrates the gains that would be made for both males and females in Nairobi upon the elimination of single diseases. The highest gains in life expectancy are realized upon the elimination of malaria among both males and females with the gains among the females being higher. At the younger ages, the elimination of tuberculosis and malaria had the same effect on gains realized in life expectancies for females. Deleting pneumonia, AIDS, tuberculosis or malaria would have life expectancies at birth among males rise by 25, 27, 26 and 28 years and rise by 18, 20, 20 and 20 years respectively among females. The gains realized above age 65 years are minimal for both sexes.

Table 5.13 Specific Cause Elimination Nairobi

	Males					Females			
	All Diseases	All but Pneumonia	All but AIDS	All but Tuberculosis	All but Malaria	All Diseases	All but Pneumonia	All but AIDS	All but Tuberculosis
Age	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$	$e_{(x)}$
0-4	50.0	75.2	76.8	76.2	77.7	58.3	76.4	77.9	78.2
5-9	51.7	72.6	72.1	71.4	73.5	60.9	73.8	73.2	73.3
10-14	47.6	67.9	67.1	66.5	68.6	56.3	69.0	68.2	68.3
15-19	43.1	63.0	62.2	61.5	63.7	51.6	64.0	63.2	63.3
20-24	38.8	58.0	57.2	56.6	58.7	47.0	59.0	58.2	58.4
25-29	34.5	53.1	52.2	51.6	53.8	42.5	54.1	53.3	53.4
30-34	30.5	48.2	47.3	46.8	48.8	38.3	49.2	48.5	48.6
35-39	27.1	43.3	42.7	42.3	44.0	34.4	44.3	43.8	43.8
40-44	23.9	38.5	38.2	37.8	39.1	30.6	39.4	39.1	39.0
45-49	20.9	33.8	33.8	33.3	34.2	26.7	34.5	34.4	34.3
50-54	17.9	29.0	29.3	28.7	29.4	22.9	29.6	29.7	29.5
55-59	14.6	24.2	24.5	24.0	24.5	19.1	24.7	24.8	24.7
60-64	11.7	19.5	19.7	19.4	19.6	15.4	19.7	19.9	19.8
65-69	9.3	14.7	14.9	14.7	14.8	12.0	14.8	15.0	14.9
70-74	6.8	9.9	9.9	9.9	9.9	8.4	9.9	10.0	10.0
75+	4.2	4.9	5.0	4.9	5.0	4.6	5.0	5.0	5.0

Source: Computed from Death Registration data, 1999 & Population Census, 1999

5.4.2 Effects of Specific Causes of Death in Nyeri

Pneumonia, HIV/AIDS, malaria and stroke/sudden death were the leading causes of death in Nyeri district. Table 5.14 shows the effects of elimination of single cause for males and females. The elimination of stroke/sudden death would lead to a higher gain in duration of life among females whereas the elimination of malaria has a greater effect at birth among the males. In the age group 5-9 among the males, the elimination of AIDS leads to higher gain in life expectancy. Above age 35, the elimination of pneumonia among males results in a higher increase in duration of life for the males.

The deletion of any of the four leading causes of death in Nyeri district leads to higher realization in life expectancies among males than females at all ages except for the deletion of malaria which results to higher life expectancy at birth among females.

Table5.14 Specific Cause Elimination Nyeri

	Males					Females				
	All Diseases	All but Pneumonia	All but AIDS	All but Malaria	All but Stroke	All Diseases	All but Pneumonia	All but AIDS	All but Malaria	All but
Age	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(
0-4	60.0	79.5	79.4	79.7	79.7	60.5	76.3	76.2	77.9	78
5-9	58.4	74.6	75.9	75.1	74.8	59.6	71.3	73.1	73.2	73
10-14	53.8	69.6	69.7	69.8	69.7	55.0	66.4	68.2	68.3	68
15-19	49.0	64.5	64.6	64.7	64.7	50.1	61.4	63.2	63.3	63
20-24	44.3	59.5	59.5	59.8	59.7	45.5	56.4	58.2	58.3	58
25-29	40.2	54.5	54.7	54.8	54.7	41.3	51.7	53.3	53.4	54
30-34	36.0	49.7	49.6	49.8	49.7	37.6	47.2	48.6	48.5	49
35-39	32.4	45.1	44.8	44.8	44.7	34.4	43.0	43.7	43.7	44
40-44	29.0	40.3	39.7	39.9	39.7	31.2	38.7	39.0	38.8	39
45-49	25.5	35.2	34.6	34.9	34.8	27.5	34.1	34.2	33.9	34
50-54	22.1	30.0	29.8	29.9	29.8	23.8	29.5	29.3	29.2	29
55-59	18.6	25.0	24.8	24.9	24.8	20.0	24.8	24.4	24.2	24
60-64	14.9	20.0	19.8	19.9	19.9	16.1	19.9	19.5	19.4	19
65-69	11.5	14.9	14.9	14.9	14.8	12.6	14.9	14.7	14.7	14
70-74	8.0	10.0	9.8	10.0	10.0	8.6	9.9	9.8	9.8	9
75+	4.6	5.0	5.0	5.0	5.0	4.6	5.0	5.0	5.0	5

Source: Computed from Death Registration data, 1999 & Population Census, 1999

5.4.3 Effects of Specific Causes of Death in Bungoma

Malaria, pneumonia, anaemia and AIDS were the four leading causes of death in Bungoma district. Table 5.15 demonstrates the effects of elimination of malaria, pneumonia, anaemia or HIV/AIDS in Bungoma district. The elimination of HIV/AIDS has the greatest effect on duration of life for both males and females at birth. Above age 5, the highest gains are realized upon the elimination of anaemia for both males and females.

Deleting malaria, pneumonia, anaemia or AIDS, as a cause of death among males would have produced increments of 10, 15, 16 and 17 years respectively and 7, 11, 12 and 12 years respectively among females at birth. Overall gains among males were higher than the gains realized among females. However, the resultant life expectancies upon the deletion of AIDS are similar for both sexes.

Table5.15 Specific Cause Elimination Bungoma

	Males					Females				
	All Diseases	All but Malaria	All but Pneumonia	All but Anaemia	All but AIDS	All Diseases	All but Malaria	All but Pneumonia	All but Anaemia	All but AIDS
Age	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)	e(x)
0-4	62.3	72.3	77.9	78.9	79.2	67.1	74.1	78.2	79.0	79.2
5-9	64.6	72.4	74.1	74.4	74.2	69.0	73.2	74.3	74.5	74.2
10-14	60.2	67.7	69.2	69.5	69.2	64.4	68.4	69.4	69.5	69.2
15-19	55.5	62.9	64.2	64.5	64.2	59.6	63.5	64.4	64.5	64.2
20-24	50.8	58.0	59.2	59.6	59.2	54.9	58.6	59.4	59.6	59.2
25-29	46.3	53.1	54.3	54.6	54.3	50.2	53.7	54.5	54.6	54.3
30-34	42.1	48.2	49.3	49.6	49.3	45.9	48.8	49.5	49.7	49.4
35-39	37.8	43.3	44.4	44.6	44.4	41.4	43.9	44.6	44.7	44.5
40-44	33.7	38.5	39.5	39.7	39.6	37.1	39.1	39.7	39.7	39.6
45-49	29.6	33.7	34.5	34.7	34.7	32.7	34.3	34.8	34.8	34.7
50-54	25.6	29.0	29.6	29.8	29.8	28.2	29.4	29.8	29.8	29.8
55-59	21.5	24.2	24.7	24.8	24.9	23.7	24.5	24.8	24.8	24.9
60-64	17.4	19.4	19.7	19.8	19.9	19.2	19.6	19.9	19.9	19.9
65-69	13.2	14.5	14.8	14.9	14.9	14.8	14.7	14.9	15.0	15.0
70-74	8.9	9.7	9.8	9.9	10.0	10.1	9.8	9.9	10.0	10.0
75+	4.7	4.9	5.0	5.0	5.0	5.6	4.9	5.0	5.0	5.0

Source: Computed from Death Registration data, 1999 & Population Census, 1999

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

This study set to estimate completeness of death registration, generate mortality life tables and thereafter compare the results with those derived from child survival and orphanhood data. The study also set to asses the effects of specific causes of death on mortality in the study districts. The sources of data were the 1989 and 1999 censuses and death registration data from the Civil Registration Department for the year 1999.

The Brass Growth Balance Method and the Bennett-Horiuchi method were applied in the study to estimate the death registration completeness and to generate mortality life tables. The multiple-decrement life table techniques were used to assess the effects of specific causes of death on mortality. The Brass Growth Balance Method is based on the stable population model whereas the Bennett-Horiuchi Method is an extension of the stable population model that assumes non-stability. Both methods assume that the population is closed and death registration is not age-dependent.

The Brass Growth Balance technique is limited by the fact that the adjustment factor is subjective if the data is distorted. The effectiveness of the technique is also limited by distortions caused by migration, age-dependent death registration and severe age-misstatement and therefore the results should be treated with caution.

The Bennett-Horiuchi method attempts to reproduce the age distribution of the population from the distribution of the deaths registered. Completeness of the registration of deaths is derived from the median values of the sequence of ratios, ${}_{10}N^*_{x-5}(x)/{}_{10}N_{x-5}(x)$. However, migration, age misstatement, age-dependent registration and differential enumeration of successive censuses can limit the effectiveness of the technique and thus the results derived from this method should also be treated with caution.

The results obtained in this study are varied and in some instances the differences are quite significant. In Bungoma, the application of the Brass Growth Balance method showed that males were over registered by 5 percent and females under registered by 23.8 percent. In Nairobi and Nyeri, males were under registered by 44.6 percent and over registered by 27 percent whereas females were over registered by 38 percent and under registered by 6 percent respectively. The results obtained upon the application of Bennett-Horiuchi model shows that males were under registered by 39 percent, under registered by 44 percent and over registered by 22 percent in Nairobi, Nyeri and Bungoma districts respectively. The females were over registered by 30 percent, under registered by 58.5 percent and under registered by 5.5 percent in Nairobi, Nyeri and Bungoma districts respectively.

A comparison of the life expectancies computed from the two methods and the results derived from the census showed that in Nairobi, the Brass Growth Balance method under estimated the life expectancies for males from ages 5 to 55 and over estimated at ages above 60. The Bennett-Horiuchi method over estimated the life expectancies for males at all the ages. Life expectancies for females were under estimated at all ages by the Brass

Growth Balance method whereas the Bennett-Horiuchi method over estimated the life expectancies at all ages.

In Nyeri, the two methods over estimated the life expectancies for males at all ages below 70 while the Brass Growth Balance method under estimated the life expectancies for females at all ages. The Bennett-Horiuchi method over estimated the life expectancies for females at ages 5 to 20 and at ages 40 and above while the life expectancies at ages 25 to 35 were under estimated.

In Bungoma, the Brass Growth Balance method over estimated the life expectancies for males at ages 5 to 50 and under estimated at ages 60 and above whereas the Bennett-Horiuchi method over estimated the life expectancies at all ages. For females in Bungoma, the Bennett-Horiuchi method over estimated the life expectancies at all ages below 70 whereas the Brass Growth Balance method over estimated the life expectancies at ages 5 to 25 and under estimated at ages 30 and above.

The elimination of single causes of death indicate that significant gains would be realized in life expectancies for both sexes in all the districts. The elimination of malaria would have the highest gains in life expectancy for both males and females in Nairobi whereas elimination of stroke would have the biggest effect on life expectancies in Nyeri for both males and females. In Bungoma district, the elimination of anaemia would have a significant effect on the life expectancies.

This study has therefore demonstrated that data collected through the civil registration system have considerable value as a source of mortality information. A variety of distortions, which include migration, differential census enumeration, age misreporting and age dependent registration had some effects on the completeness and mortality estimates.

The two methods applied in this study, have to some extent given comparable results for both completeness and life expectancy estimates. The estimates for completeness derived from the Brass Growth Balance Method are fairly close to the estimates derived by the Bennett-Horiuchi method in Nairobi for both males and females. There are however markedly significant differences in the estimates obtained for Nyeri district for both males and females. Whereas the Brass method gave reasonably good estimates for death registration completeness in Nyeri district, the Bennett-Horiuchi method under estimated the completeness levels.

The use of the two methods demonstrates the importance of applying different estimation procedures as a consistency check. From the results in this study we see that different estimation techniques are sensitive to a variety of possible sources of distortions in different ways.

From the results generated from the two methods and the subsequent comparison with the results generated from orphan hood data in the census, it is evident that the agreement in the results is limited. This may be attributed to the use of different data sets, the application of different methodologies and the inherent errors in the data sets. It is also apparent that the assumptions under which the models were developed are not met in most of the cases.

It also emerges from the results that elimination of the major causes of death would have significant impact on the duration of life in all the districts. The gains in life expectancies were over 20 years in younger age groups for most causes eliminated. This means that reductions of the leading causes of death by some percent would have far reaching implications on the health status of the population and also on the national economic productivity.

6.2 Recommendations

This section looks at both policy and research recommendations. These are recommendations which, it is felt would improve on mortality estimations and on the planning and programming in the health sector.

6.2.1 Policy Recommendations.

Data from the civil registration system has not been analysed for a long time. This has made the importance of these data to be disregarded by both the Government and other major institutions in the country e.g. the Health sector. It is also important to note that various organizations in the country hold vital information on the population and if linkages were to be developed then this would assist a lot in addressing some of the errors observed in the results. It would therefore be important for the following policy measures to be addressed as a way of improving the generation and analysis of the data and hence the improvement of the health status of the population.

1. Infectious and parasitic diseases are the major causes of death in the three districts but HIV/AIDS has more elaborate and comprehensive programmes developed to combat it. To improve on life expectancies of the population, the Government should integrate the HIV/AIDS programmes with other programmes targeting different diseases.
2. The study has demonstrated that data based on the civil registration system have considerable value as a source of mortality information and it is therefore important researchers are actively involved in its capture and analysis so that the information generated can supplement and verify the information collected through censuses and sample surveys.
3. Apart from Nairobi district, the degree of completeness in the other districts shows that females were under registered. This implies that the overall registration in rural areas among the females is not complete. This therefore calls for a review of the registration procedures in the rural areas. The bottlenecks identified such as motivation and lack of transport for the Chiefs and their Assistants must be addressed.
4. To improve on the reliability of autopsies, it is important that standard guidelines are developed targeting deaths that occur at home. However, in long-term term, the Government must expand health facilities in rural areas and train more personnel qualified to handle autopsies.

6.2.2 Recommendations for further research.

The study has demonstrated that different methodologies and the use of different data sets have effects on the mortality results. It is therefore important that the mortality questions respondents are asked in censuses and sample surveys be reviewed. Research should focus more on the effectiveness of direct questions on the number of deaths in households.

The dependence on mortality life tables that were developed more than 30 years ago should also be reviewed to determine their suitability under the changing demographic and epidemiological conditions in the Kenyan population.

It has been observed from the study that there are differences in the mortality levels in the study districts as estimated by life expectancies. Research should therefore be carried out to determine the causal factors.

REFERENCES

Barclay, G.W. (1958). Techniques of Population Analysis, New York

Bennett N.G. and Horiuchi S. (1984). 'Mortality Estimation from Registration Deaths in Less Developed Countries', Population Studies Vol.21 (2): pp: 217-234.

Bennett N., and S. Horiuchi (1981). 'Estimating the Completeness of Death Registration in a Closed Population'. Population Index 47(2): 207-21.

Bicego G. et al. (1997). In-depth Study on Estimating Adult and Childhood Mortality in Settings of High Adult Mortality. Calverton, Maryland.

Blacker J.G.C (1977). 'Estimation of Adult Mortality in Africa from Data on Orphanhood', Population Studies Vol.31 (1) pp.107-28.

Central Bureau of Statistics (2002). Kenya Population and Housing Census, 1999. Analytical Report on Mortality, Vol. V

Central Bureau of Statistics (2002). Kenya Population and Housing Census, 1989, Vol.1

Central Bureau of Statistics (2002). Kenya Population and Housing Census, 1999, Vol.1

Conception, M. (1980). 'Factors in the Decline of Mortality in the Philippines', Mortality in South and East Asia A Review of Changing Trends and Patterns, 1950-1975. Manilla

Division of Health Information System. 2000. Ministry of Health.

Fleiger. W (1980). 'Philippine Mortality: Levels, Trends and Area Differentials', Mortality in South and East Asia a Review of Changing Trends and Patterns, 1950-1975. Manilla

Hansluwka, H. and Ruzicka, L. (1980): 'The Health Spectrum in South and East Asia', Mortality in South and East Asia A Review of Changing Trends and Patterns, 1950-1975. Manilla

Kenneth G. Manton (1982). Temporal Trends in U.S Multiple Cause of Death Mortality Data: 1968 to 1977.

Keyfitz N. (1977). Applied Mathematical Demography. New York

Kizito, M.L (1985). "The Estimation of Adult Mortality Differentials in Kenya using a Life Table Technique". Unpublished Msc Thesis, University of Nairobi.

K'Oyugi, B.O. (1981-2). 'Mortality and Morbidity Situation in Siaya District'. Unpublished Msc Thesis, University of Nairobi.

Kpedekpo G.M.K. (1982). The Essentials of Demographic Analysis for Africa.

Martin .L. G. (1980). 'A modification for Use in Destabilized Populations of Brass's Technique for Estimating Completeness of Death Registration', Population Studies Vol. 34(2). Pp381-396.

Makoteku, J.O. " Estimating the Degree of Completeness of Death Registration in Kenya in 1979", Population Studies and Research Institute University of Nairobi and Population Studies Centre, University of Pennsylvania, USA

Mott, F.L. (1979). 'Infant Mortality in Kenya: Evidence from the Kenya Fertility Survey'. Population Studies and Training Centre.

Nyokang'i J.J. (1984). 'Mortality Estimates in Kenya with special reference to Cause of Death'. Unpublished Msc Thesis, University of Nairobi.

Preston, S. and Hill, K. (1980). 'Estimating the Completeness of Death Registration'. Population Studies Vol.34 (2): pp349-66.

Preston, S.H (1976). Mortality Patterns in National Populations, New York.

Ling R. Z. (1980). "A brief Account of 30 years' Mortality of Chinese Population". Mortality in South East Asia a Review of Changing Trends and Patterns, 1950-1975. Manilla

Sullivan J.M (1973). 'The Influence of Cause-Specific Mortality Conditions on the Age' Pattern of Mortality with special reference to Taiwan. Population Studies Vol.37 (1) pp 135-158.

United Nations (1983). Manual X: Indirect Techniques for Demographic Estimation, Population Studies No.81, New York

United Nations (1993). Readings in Population Research and Methodology, Vol.2

World Bank (1991). Disease and Mortality in Sub-Saharan Africa, O.U.P

World Health Organization (2002). World Mortality in 2000: Life Tables for 191 Countries. Canada

APPENDICES

Appendix 1

The ratio, ${}_{30}d_{10}$ / ${}_{20}d_{40}$, and corresponding e(x) values (x= 75, -----, 95) associated with any levels of mortality in the Coale-Demeny West model life tables, for males and females.

MALES

Table 1.1

Level	Ratio	e(75)	e(80)	e(85)	e(90)	e(95)
3	1.161	6.05	4.55	3.35	2.41	1.71
4	1.094	6.31	4.75	3.49	2.51	1.77
5	1.034	6.57	4.95	3.63	2.60	1.83
6	0.980	6.82	5.14	3.77	2.70	1.90
7	0.930	7.06	5.32	3.90	2.79	1.95
8	0.885	7.29	5.49	4.03	2.87	2.01
9	0.842	7.52	5.67	4.15	2.96	2.07
10	0.802	7.74	5.83	4.27	3.04	2.12
11	0.763	7.96	5.99	4.38	3.12	2.18
12	0.725	8.17	6.15	4.50	3.20	2.23
13	0.689	8.38	6.30	4.61	3.28	2.28
14	0.648	8.55	6.43	4.70	3.34	2.32
15	0.609	8.71	6.55	4.79	3.40	2.36
16	0.570	8.88	6.68	4.88	3.47	2.40
17	0.530	9.06	6.81	4.98	3.53	2.45
18	0.490	9.26	6.95	5.09	3.61	2.50
19	0.447	9.46	7.11	5.20	3.68	7.55
20	0.401	9.67	7.26	5.31	3.77	2.60
21	0.352	9.90	7.43	5.44	3.85	2.66
22	0.305	10.25	7.70	5.63	3.99	2.75
23	0.255	10.70	8.03	5.88	4.16	2.86
24	0.202	11.28	8.48	6.21	4.40	3.02
25	0.147	12.06	9.08	6.66	4.71	3.23

Table1.2 Females

Level	Ratio	e(75)	e(80)	e(85)	e(90)	e(95)
2	1.461	6.15				
3	1.376	6.45	4.88	3.57	2.54	1.78
4	1.300	6.75	5.11	3.73	2.65	1.86
5	1.233	7.05	5.33	3.89	2.76	1.93
6	1.171	7.34	5.54	4.04	2.87	1.99
7	1.115	7.62	5.75	4.19	2.97	2.06
8	1.062	7.89	5.95	4.33	3.07	2.12
9	1.012	8.16	6.14	4.47	3.16	2.19
10	0.954	8.42	6.33	4.61	3.26	2.25
11	0.918	8.67	6.52	4.74	3.35	2.31
12	0.872	8.92	6.70	4.88	3.44	2.37
13	0.827	9.17	6.88	5.00	3.53	2.43
14	0.787	9.37	7.02	5.11	3.60	2.47
15	0.729	9.56	7.16	5.21	3.67	2.52
16	0.673	9.77	7.32	5.33	3.75	2.57
17	0.617	9.99	7.48	5.44	3.83	2.63
18	0.660	10.23	7.65	5.57	3.92	2.68
19	0.501	10.48	7.83	5.70	4.01	2.74
20	0.488	10.73	8.01	5.84	4.11	2.80
21	0.365	11.01	8.22	5.99	4.21	2.87
22	0.298	11.44	8.54	6.22	4.38	2.98
23	0.235	11.97	8.94	6.62	4.69	3.12
24	0.175	12.65	9.46	6.91	4.86	3.10
25	0.117	13.52	10.17	7.45	5.24	3.84

Source: Bennett N.G. and Horiuchi, 1982 op. cit., pp11.

Table 1.3
Coefficients for Estimating z(A) from the Ratio of Deaths 45+ to Deaths 10+ and the Population Growth Rate.

1	2	3	4	5
Regional Family	A	a(A)	b(B)	c(A)
West	45	-13.43	181.40	17.57
	50	-12.49	163.60	15.49
	55	-11.24	143.70	13.34
	60	-9.50	121.20	11.07
	65	-7.21	96.10	8.57
	70	-4.48	69.20	6.23
	75	-1.64	42.90	3.91
	80	-0.72	20.50	1.98
	85	2.03	5.90	0.70

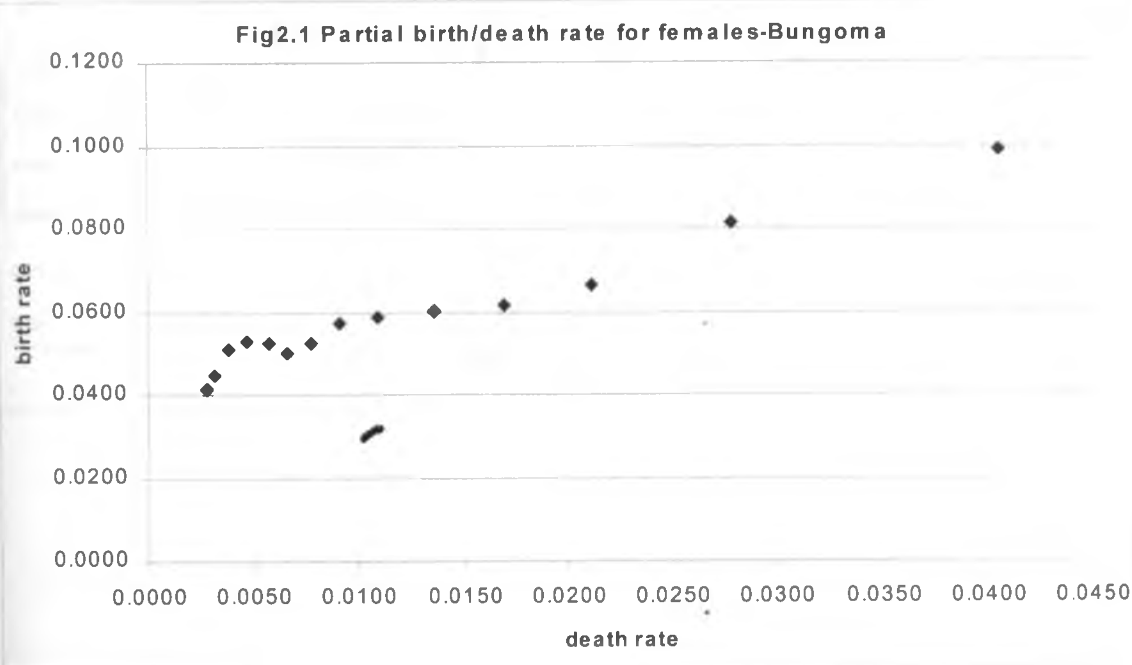
Source: Hill, K and H. Zlotnik, 1982 op. cit. pp 21.

Appendix 2

Table 2.1 Partial Rates Females Bungoma
Based on Brass method

Age	N(x)	N(x+)	D(x+)	Partial Death rate	Partial Birth rate
5	15107	366499	1027	0.0028	0.0412
10	13327	298840	944	0.0032	0.0446
15	11907	233234	893	0.0038	0.0510
20	9561	179775	843	0.0047	0.0532
25	7258	137618	793	0.0058	0.0527
30	5397	107193	705	0.0066	0.0504
35	4394	83639	649	0.0078	0.0525
40	3612	63246	576	0.0091	0.0571
45	2782	47517	517	0.0109	0.0586
50	2134	35417	481	0.0136	0.0603
55	1615	26177	444	0.0170	0.0617
60	1282	19264	408	0.0212	0.0666
65	1088	13350	372	0.0279	0.0816
70	825	8376	340	0.0406	0.0986

Source: Computed from Death Registration Data & Population Census, 1999

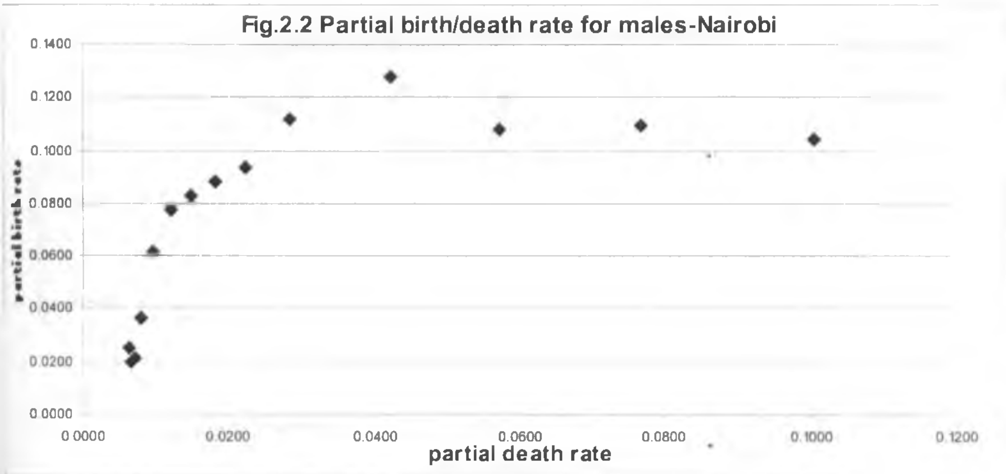


Source: Derived from death registration data, 1999.

Table 2.2 Partial Rates Males Nairobi
Based on Brass method

Age	N(x)	N(x+)	D(x+)	Partial death rate	Partial birth rate
5	24589.6	988800	6195	0.0063	0.0249
10	17790.9	891478	5969	0.0067	0.0200
15	17202.4	810891	5861	0.0072	0.0212
20	26036.3	719454	5673	0.0079	0.0362
25	33926.9	550528	5288	0.0096	0.0616
30	29370.3	380185	4636	0.0122	0.0773
35	21207.2	256825	3839	0.0149	0.0826
40	14793.6	168113	3057	0.0182	0.0880
45	10204.1	108889	2428	0.0223	0.0937
50	7377.8	66072	1880	0.0285	0.1117
55	4492.4	35111	1485	0.0423	0.1279
60	2279.2	21148	1208	0.0571	0.1078
65	1352.6	12319	946	0.0768	0.1098
70	794.4	7622	767	0.1006	0.1042

Source: Computed from Death Registration Data & Population Census, 1999

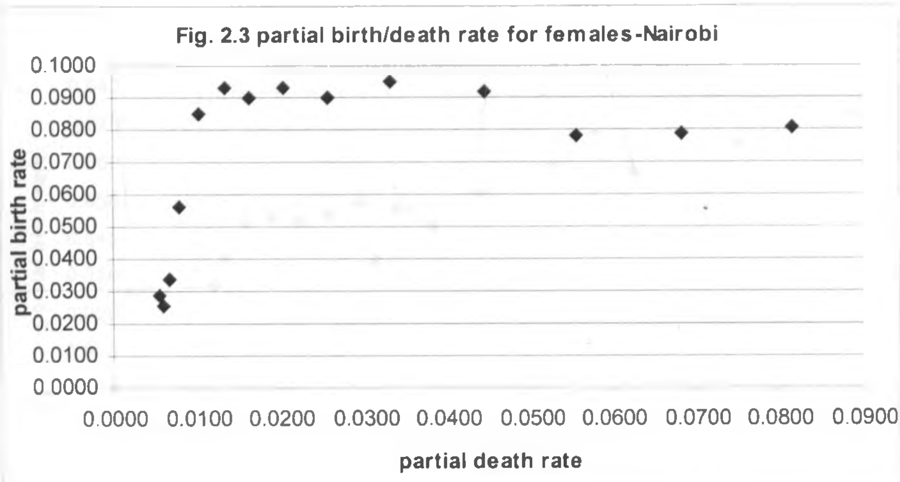


Source: Derived from death registration data, 1999.

Table 2.3 Nairobi Females Based on Brass method

Age	N(x)	N(x+)	D(x+)	partial death rate	partial birth rate
5	24106.1	834269	4706	0.0056	0.0289
10	18963.8	736104	4511	0.0061	0.0258
15	21560.2	644631	4391	0.0068	0.0334
20	29323.7	520502	4162	0.0080	0.0563
25	29833.4	351394	3670	0.0104	0.0849
30	20662.3	222168	2977	0.0134	0.0930
35	13067.4	144771	2357	0.0163	0.0903
40	8514.3	91494	1867	0.0204	0.0931
45	5357.2	59628	1532	0.0257	0.0898
50	3602.4	37922	1261	0.0333	0.0950
55	2166.9	23604	1051	0.0445	0.0918
60	1268.9	16253	902	0.0555	0.0781
65	857.4	10915	746	0.0683	0.0786
70	618.4	7679	627	0.0817	0.0805

Source: Computed from Death Registration Data & Population Census, 1999

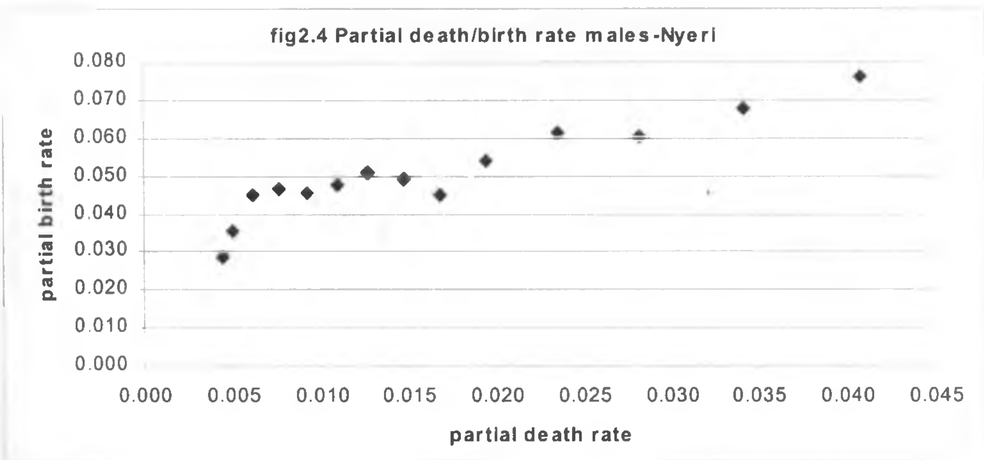


Source: Derived from death registration data, 1999.

Table 2.4 Partial Rates Nyeri Males Based on Brass method

Age	N(x)	N(x+)	D(x+)	Partial death rate	Partial birth rate
5	7962.1	277993	1247	0.0045	0.0286
10	8458.9	239622	1216	0.0051	0.0353
15	8705.0	193404	1201	0.0062	0.0450
20	7147.8	152572	1174	0.0077	0.0468
25	5558.6	121926	1123	0.0092	0.0456
30	4611.2	96986	1067	0.0110	0.0475
35	3862.1	75814	965	0.0127	0.0509
40	2865.1	58365	863	0.0148	0.0491
45	2127.6	47163	794	0.0168	0.0451
50	2012.4	37089	720	0.0194	0.0543
55	1656.4	27039	636	0.0235	0.0613
60	1238.2	20525	579	0.0282	0.0603
65	993.5	14657	501	0.0342	0.0678
70	805.6	10590	432	0.0408	0.0761

Source: Computed from Death Registration Data & Population Census, 1999

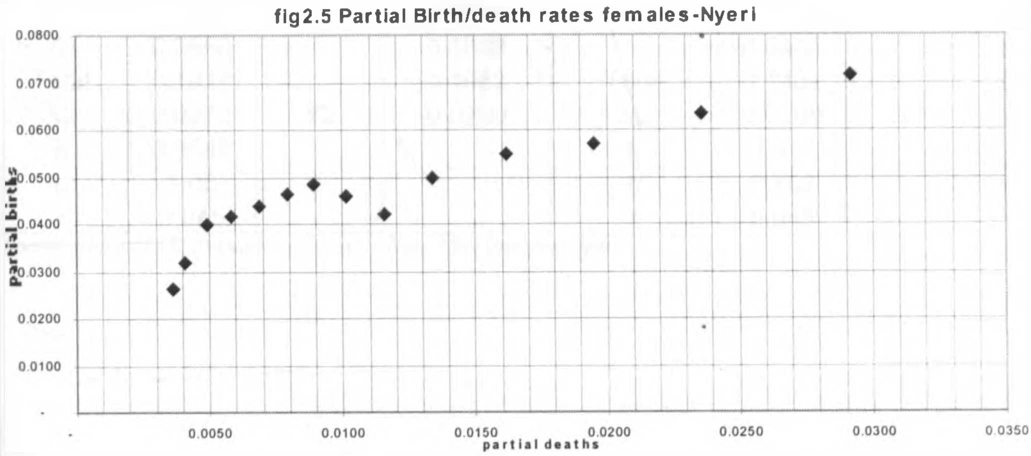


Source: Derived from death registration data, 1999.

Table 2.5 Partial Rates Nyeri Females Based on Brass method

Age	N(x)	N(+)	D(x+)	Partial death rate	Partial Birth rate
5	7766.8	296711	1073	0.0036	0.0262
10	8320.9	259007	1050	0.0041	0.0321
15	8521.3	213502	1041	0.0049	0.0399
20	7275.9	173794	1017	0.0059	0.0419
25	6143.4	140743	966	0.0069	0.0436
30	5197.1	112360	890	0.0079	0.0463
35	4292.7	88772	792	0.0089	0.0484
40	3176.3	69433	702	0.0101	0.0457
45	2397.9	57009	658	0.0115	0.0421
50	2259.7	45454	609	0.0134	0.0497
55	1893.7	34412	557	0.0162	0.0550
60	1506.4	26517	518	0.0195	0.0568
65	1227.7	19348	457	0.0236	0.0635
70	1016.8	14240	416	0.0292	0.0714

Source: Computed from Death Registration Data & Population Census, 1999



Source: Derived from death registration data, 1999.

Table 2.6 Computation of Completeness of Death Registration in Bungoma Based on Brass method

	Male Partial Death rate		Partial Birth rate		Female Partial Death rate		Partial Birth rate
Age	Group1				Group1		
5	0.0035		0.0443		0.0028		0.0412
10	0.0040		0.0479		0.0032		0.0446
15	0.0049		0.0555		0.0038		0.0510
20	0.0062		0.0562		0.0047		0.0532
25	0.0075		0.0517		0.0058		0.0527
30	0.0089		0.0493		0.0066		0.0504
35	0.0106		0.0520		0.0078		0.0525
Total	0.0454		0.3570	Total	0.0346		0.3457
X1	0.0065	Y1	0.0510	X1	0.0049	Y1	0.0494
	Group2				Group2		
40	0.0126		0.0578		0.0091		0.0571
45	0.0154		0.0600		0.0109		0.0586
50	0.0187		0.0617		0.0136		0.0603
55	0.0231		0.0621		0.0170		0.0617
60	0.0288		0.0663		0.0212		0.0666
65	0.0378		0.0834		0.0279		0.0816
70	0.0550		0.1049		0.0406		0.0986
Total	0.1914		0.4962	Total	0.1402		0.4844
X2	0.0273	Y2	0.0709	X2	0.0200	Y2	0.069
k	0.9542			k	1.313		
c	1.05			c	0.762		
r	0.045			r	0.043		

Source: Computed from Death Registration Data, 1999 Bungoma district

Table 2.7 Computation of Completeness of Death Registration in Nairobi Based on Brass method

		Males Partial Death rate		Partial Birth rate		Females partial Death rate		Partial Birth rate
Age	Weights	Group1			Weights	Group1		
5	0.25	0.0063		0.0249	0.25	0.0056		0.0289
10	0.50	0.0067		0.0200	0.50	0.0061		0.0258
15	0.75	0.0072		0.0212	0.75	0.0068		0.0334
20	1.00	0.0079		0.0362	1.00	0.0080		0.0563
25	1.00	0.0096		0.0616	1.00	0.0104		0.0849
30	1.00	0.0122		0.0773	1.00	0.0134		0.0930
35	1.00	0.0149		0.0826	1.00	0.0163		0.0903
Total	5.50	0.0550		0.2897	5.50	0.0577		0.3697
Mean	X*1	0.0100	Y*1	0.0527	X*1	0.0105	Y*1	0.0672
		Group2				Group2		
40	1.00	0.0182		0.0880	1.00	0.0204		0.0931
45	1.00	0.0223		0.0937	1.00	0.0257		0.0898
50	1.00	0.0285		0.1117	1.00	0.0333		0.0950
55	1.00	0.0423		0.1279	1.00	0.0445		0.0918
60	0.75	0.0571		0.1078	0.75	0.0555		0.0781
65	0.50	0.0768		0.1098	0.50	0.0683		0.0786
70	0.25	0.1006		0.1042	0.25	0.0817		0.0805
Total	5.50	0.2176		0.5831	5.50	0.2201		0.4877
Mean	X*2	0.0396	Y*2	0.1060	X*2	0.0400	Y*2	0.0887
	K	1.804			k	0,73		
	C	0.554			c	1.38		
	R	0.035			r	0.060		

Source: Computed from Death Registration Data, 1999 Nairobi

Table 2.8 Computation of Completeness of Death Registration based on Brass method in Nyeri

Age	Weights	Male Partial Death rate		Partial Death rate	Age	Weights	Female Partial death rate Group1		Partial Birth Rate
5	0.25	0.0045		0.0286	5	0.25	0.0036		0.0262
10	0.50	0.0051		0.0353	10	0.50	0.0041		0.0321
15	0.75	0.0062		0.0450	15	0.75	0.0049		0.0399
20	1.00	0.0077		0.0468	20	1.00	0.0059		0.0419
25	1.00	0.0092		0.0456	25	1.00	0.0069		0.0436
30	1.00	0.0110		0.0475	30	1.00	0.0079		0.0463
35	1.00	0.0127		0.0509	35	1.00	0.0089		0.0484
Total	5.50	0.0490		0.2495	Total	5.50	0.0361		0.2327
Mean	X*1	0.0089	Y*1	0.0454	Mean	X*1	0.0066	Y*1	0.0423
		Group2					Group2		
40	1.00	0.0148		0.0491	40	1.00	0.0101		0.0457
45	1.00	0.0168		0.0451	45	1.00	0.0115		0.0421
50	1.00	0.0194		0.0543	50	1.00	0.0134		0.0497
55	1.00	0.0235		0.0613	55	1.00	0.0162		0.0550
60	0.75	0.0282		0.0603	60	0.75	0.0195		0.0568
65	0.50	0.0342		0.0678	65	0.50	0.0236		0.0635
70	0.25	0.0408		0.0761	70	0.25	0.0292		0.0714
Total	5.50	0.1230		0.3079	Total	5.50	0.0850		0.2847
Mean	X*2	0.0224	Y*2	0.0560	Mean	X*2	0.0155	Y*2	0.0518
	k	0.79				k	1.07		
	c	1.27				c	0.94		
	r	0.04				r	0.04		

Source: Computed from Death Registration Data, 1999 Nyeri

Appendix 3

Table 3.1 Estimation of Completeness Nairobi Males Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x(x)$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	0.0514	2186	148574	60325.3	262617.7	
5	0.0399	226	97322	44721.8	202859.0	1.89
10	0.0484	108	80587	36421.8	162304.9	2.05
15	0.0494	188	91437	28500.1	126486.9	1.68
20	0.0357	385	168926	22094.6	100552.0	0.87
25	0.0347	652	170343	18126.2	81909.8	0.54
30	0.0421	797	123360	14637.7	64446.5	0.50
35	0.0432	782	88712	11140.9	48538.1	0.53
40	0.0346	629	59224	8274.3	36645.1	0.58
45	0.0442	548	42817	6383.7	27529.3	0.63
50	0.0479	395	30961	4628.0	19799.0	0.64
55	0.0344	277	13963	3291.5	14521.8	0.76
60+	0.0538	1208	21148	2517.1		
Z(60)	13.65				Median	64
D(45+)	2428					
D(10+)	5969					

Source: Computed from Death Registration Data 1999 & Population Census, 1989&1999

Table 3.2 Estimation of Completeness Males Nairobi Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	0.0514	2186	148574	57160	248584	
5	0.0399	226	97322	42274	191728	1.79
10	0.0484	108	80587	34417	153359	1.94
15	0.0494	188	91437	26926	119479	1.59
20	0.0357	385	168926	20865	94908	0.82
25	0.0347	652	170343	17098	77179	0.51
30	0.0421	797	123360	13774	60536	0.47
35	0.0432	782	88712	10441	45378	0.50
40	0.0346	629	59224	7710	34049	0.54
45	0.0442	548	42817	5909	25392	0.58
50	0.0479	395	30961	4248	18099	0.59
55+	0.0456	1485	35111	2992		
Z(55)	15.35				Median	58.5
D(45+)	2428					
D(10+)	5969					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989&1999

Table 3.3 Estimation of Completeness Nairobi Males Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	0.0514	2186	148574	58782	255775	
5	0.0399	226	97322	43528	197432	1.84
10	0.0484	108	80587	35444	157943	2.00
15	0.0494	188	91437	27733	123070	1.63
20	0.0357	385	168926	21495	97800	0.85
25	0.0347	652	170343	17625	79603	0.52
30	0.0421	797	123360	14216	62540	0.48
35	0.0432	782	88712	10800	46997	0.52
40	0.0346	629	59224	7999	35379	0.56
45	0.0442	548	42817	6152	26487	0.61
50+	0.0467	1880	66072	4443		
Z(50)	18.42				Median	61
D(45+)	2428					
D(10+)	5969					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989&1999

Table 3.4 Estimation of Completeness Nyeri Males Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	-0.0114	270	41250	3429	16954	
5	-0.0244	31	38371	3353	17771	0.44
10	0.0015	15	46218	3755	18671	0.43
15	0.0107	27	40832	3713	18016	0.42
20	0.0143	51	30646	3494	16742	0.49
25	0.0220	56	24940	3203	15050	0.57
30	0.0499	102	21172	2817	12303	0.59
35	0.0447	102	17449	2105	9242	0.56
40	0.0102	69	11202	1592	7593	0.59
45	0.0248	74	10074	1445	6631	0.67
50	0.0415	84	10050	1207	5281	0.59
55	0.0305	57	6514	905	4074	0.56
60+	0.0163	579	20525	724		
					Median	0.56
Z(60)	13.74	13.74				
D(45+)	794					
D(10+)	1216					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.5 Estimation of Completeness Nyeri Males Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	$N^*(x)$	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{x-5}$
0	-0.0114	270	41250	3390.7	16757.9	
5	-0.0244	31	38371	3312.5	17555.4	0.43
10	0.0015	15	46218	3709.7	18443.1	0.43
15	0.0107	27	40832	3667.5	17795.4	0.42
20	0.0143	51	30646	3450.6	16534.7	0.48
25	0.0220	56	24940	3163.2	14860.3	0.56
30	0.0499	102	21172	2780.9	12143.9	0.59
35	0.0447	102	17449	2076.7	9116.0	0.55
40	0.0102	69	11202	1569.7	7484.5	0.58
45	0.0248	74	10074	1424.1	6531.1	0.66
50	0.0415	84	10050	1188.3	5195.8	0.58
55+	0.0195	636	27039	890.0		
					Median	0.55
Z(55)	17.19					
D(45+)	794					
D(10+)	1216					

Source: Computed from Death Registration Data, 1999 & Population Census, 1999 & 1989

Table 3.6 Estimation of Completeness Nyeri Males Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	$N^*(x)$	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{x-5}$
0	-0.0114	270	41250	3473.5	17183.9	
5	-0.0244	31	38371	3400.1	18022.0	0.44
10	0.0015	15	46218	3808.7	18936.4	0.44
15	0.0107	27	40832	3765.8	18274.1	0.43
20	0.0143	51	30646	3543.8	16984.5	0.49
25	0.0220	56	24940	3250.0	15271.4	0.58
30	0.0499	102	21172	2858.6	12489.6	0.60
35	0.0447	102	17449	2137.2	9388.5	0.57
40	0.0102	69	11202	1618.2	7720.6	0.60
45	0.0248	74	10074	1470.1	6747.7	0.68
50+	0.0250	720	37089	1229.0		
					Median	0.57
Z(50)	21.36	21.36				
D(45+)	794					
D(10+)	1216					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.7 Estimation of Completeness Nairobi females Based on Bennett-Horiuchi method

Age	${}_5r_x$	${}_5D_x$	${}_5N_x$	N*(x)	${}_5N^*_x$	${}_{10}N^*_{x-5}(x)/{}_{10}N_{X-5}$
0	0.0495	1822	142896	95711.9	422069.4	
5	0.0371	195	98165	73115.8	334181.8	3.14
10	0.0477	120	91473	60556.9	270393.0	3.19
15	0.0545	229	124129	47600.3	209118.9	2.22
20	0.0581	492	169108	36047.2	156450.4	1.25
25	0.0545	693	129226	26532.9	115336.9	0.91
30	0.0621	620	77397	19601.8	83606.9	0.96
35	0.0628	490	53277	13840.9	58827.6	1.09
40	0.0616	335	31866	9690.1	41310.7	1.18
45	0.0730	271	21706	6834.2	28379.9	1.30
50	0.0764	210	14318	4517.8	18568.9	1.30
55	0.0639	149	7351	2909.8	12242.6	1.42
60+	0.0596	902	16253	1987.3		
Z(60)	13.26				Median	130
D(45+)	1532					
D(10+)	4511					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.8 Estimation of Completeness Nairobi females Based on Bennett-Horiuchi method

Age	${}_5r_x$	${}_5D_x$	${}_5N_x$	N*(x)	${}_5N^*_x$	${}_{10}N^*_{x-5}(x)/{}_{10}N_{X-5}$
0	0.0495	1822	142896	93663	412947	
5	0.0371	195	98165	71516	326860	3.07
10	0.0477	120	91473	59228	264453	3.12
15	0.0545	229	124129	46553	204509	2.18
20	0.0581	492	169108	35250	152967	1.22
25	0.0545	693	129226	25937	112711	0.89
30	0.0621	620	77397	19148	81640	0.94
35	0.0628	490	53277	13508	57387	1.06
40	0.0616	335	31866	9447	40256	1.15
45	0.0730	271	21706	6656	27623	1.27
50	0.0764	210	14318	4394	18047	1.27
55+	0.0609	1051	23604	2825		
Z(55)	16.24				Median	124.5
D(45+)	1532					
D(10+)	4511					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.9 Estimation of Completeness Nairobi females Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	0.0495	1822	142896	100503	443398	
5	0.0371	195	98165	76856	351301	3.30
10	0.0477	120	91473	63664	284280	3.35
15	0.0545	229	124129	50048	219898	2.34
20	0.0581	492	169108	37911	164595	1.31
25	0.0545	693	129226	27927	121476	0.96
30	0.0621	620	77397	20663	88207	1.01
35	0.0628	490	53277	14619	62195	1.15
40	0.0616	335	31866	10259	43776	1.24
45	0.0730	271	21706	7252	30149	1.38
50+	0.0665	1261	37922	4808		
Z(50)	20.14				Median	131
D(45+)	1532					
D(10+)	4511					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.10 Estimation of Completeness Nyeri Females Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	-0.0122	214	39964	2715.4	13452.3	
5	-0.0246	23	37704	2665.6	14139.2	0.36
10	0.0012	9	45505	2990.1	14882.3	0.35
15	0.0082	24	39708	2962.8	14456.4	0.34
20	0.0075	51	33051	2819.7	13714.4	0.39
25	0.0189	76	28383	2666.0	12546.6	0.43
30	0.0511	98	23588	2352.7	10221.0	0.44
35	0.0426	90	19339	1735.7	7644.1	0.42
40	0.0086	44	12424	1321.9	6362.1	0.44
45	0.0173	49	11555	1222.9	5743.4	0.50
50	0.0340	52	11042	1074.4	4832.6	0.47
55	0.0366	39	7895	858.6	3845.1	0.46
60+	0.0199	518	26517	679.4	1698.6	
Z(60)	13.63	13.63				
D(45+)	658					
D(10+)	1050					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.11 Estimation of Completeness Nyeri Females Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	-0.0122	214	39964	2659.2	13162.6	
5	-0.0246	23	37704	2605.8	13821.1	0.35
10	0.0012	9	45505	2922.6	14545.7	0.34
15	0.0082	24	39708	2895.7	14127.6	0.34
20	0.0075	51	33051	2755.3	13398.3	0.38
25	0.0189	76	28383	2604.0	12250.5	0.42
30	0.0511	98	23588	2296.2	9970.7	0.43
35	0.0426	90	19339	1692.0	7446.6	0.41
40	0.0086	44	12424	1286.6	6189.3	0.43
45	0.0173	49	11555	1189.1	5581.3	0.49
50	0.0340	52	11042	1043.4	4689.6	0.45
55+	0.0235	557	34412	832.4		
Z(55)	17.10				Median	41.5
D(45+)	658					
D(10+)	1050					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.12 Estimation of Completeness Nyeri Females Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	-0.0122	214	39964	2659.0	13161.8	
5	-0.0246	23	37704	2605.7	13820.1	0.35
10	0.0012	9	45505	2922.4	14544.7	0.34
15	0.0082	24	39708	2895.5	14126.7	0.34
20	0.0075	51	33051	2755.2	13397.4	0.38
25	0.0189	76	28383	2603.8	12249.6	0.42
30	0.0511	98	23588	2296.1	9969.9	0.43
35	0.0426	90	19339	1691.9	7446.0	0.41
40	0.0086	44	12424	1286.5	6188.7	0.43
45	0.0173	49	11555	1189.0	5580.8	0.49
50+	0.0260	609	45454	1043.3		
Z(50)	20.74				Median	41
D(45+)	658					
D(10+)	1050					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.13 Estimation of Completeness Bungoma-Females Based on Bennett-Horiuchi method

Age	${}_5r_x$	${}_5D_x$	${}_5N_x$	N*(a)	${}_5N^*_x$	${}_{10}N^*_{x-5}(x)/{}_{10}N_{x-5}$
0	0.038	495	83414	22735.6	102771.2	
5	0.030	83	67659	18372.8	85222.5	1.24
10	0.049	51	65606	15716.2	69899.5	1.16
15	0.050	50	53459	12243.6	54336.6	1.04
20	0.056	50	42157	9491.0	41576.7	1.00
25	0.044	88	30425	7139.7	32011.4	1.01
30	0.048	56	23554	5664.9	25179.9	1.06
35	0.063	73	20393	4407.1	18896.9	1.00
40	0.063	59	15729	3151.7	13498.5	0.90
45	0.061	36	12100	2247.7	9675.3	0.83
50	0.051	37	9240	1622.4	7111.2	0.79
55	0.038	36	6913	1222.1	5497.5	0.78
60+	0.054	408	19264	976.9	.	
					Median	100
Z(60)	16.2					
D(45+)	517					
D(10+)	944					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.14 Estimation of Completeness Bungoma Females Based on Bennett-Horiuchi method

Age	${}_5r_x$	${}_5D_x$	${}_5N_x$	N*(x)	${}_5N^*_x$	${}_{10}N^*_{x-5}(x)/{}_{10}N_{x-5}$
0	0.038	495	83414	21353.3	96454.3	1.17
5	0.030	83	67659	17228.4	79902.1	1.09
10	0.049	51	65606	14732.4	65517.1	0.98
15	0.050	50	53459	11474.4	50915.9	0.94
20	0.056	50	42157	8892.0	38945.7	0.95
25	0.044	88	30425	6686.3	29966.1	0.99
30	0.048	56	23554	5300.1	23550.7	0.94
35	0.063	73	20393	4120.1	17656.4	0.84
40	0.063	59	15729	2942.4	12593.8	0.78
45	0.061	36	12100	2095.1	9013.2	0.73
50	0.051	37	9240	1510.1	6613.6	
55+	0.050	444	26177	1135.3		
					Median	94.5
Z(55)	18.9					
D(45+)	517					
D(10+)	944					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.15 Estimation of Completeness Bungoma Females Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x$	N*(x)	$_5N^*_x$	$_{10}N^*_{x-5}(x)/_{10}N_{X-5}$
0	0.038	495	83414	20996.3	94822.6	1.15
5	0.030	83	67659	16932.8	78527.7	1.07
10	0.049	51	65606	14478.3	64385.1	0.96
15	0.050	50	53459	11275.7	50032.3	0.92
20	0.056	50	42157	8737.2	38266.0	0.93
25	0.044	88	30425	6569.2	29437.7	0.97
30	0.048	56	23554	5205.9	23129.8	0.92
35	0.063	73	20393	4046.0	17335.9	0.82
40	0.063	59	15729	2888.3	12360.1	0.76
45	0.061	36	12100	2055.7	8842.2	
50+	0.050	481	35417	1481.2		
					Median	0.93
Z(50)	22.5					
D(45+)	517					
D(10+)	944					

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 3.16: Estimation of Completeness Bungoma-Males For A=60 Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x(x)$	N*(x)	$_5N^*_x(x)$	$_{10}N^*_{X-5}(x)/\ _{10}N_{x-5}(x)$
0	0.039	579	84160	26782	120622	
5	0.037	100	67074	21467	98107	1.45
10	0.048	66	64160	17776	79186	1.35
15	0.049	50	52283	13898	61816	1.21
20	0.056	55	36336	10828	47381	1.23
25	0.047	72	26324	8124	36175	1.33
30	0.044	57	20524	6346	28451	1.38
35	0.064	79	18204	5034	21559	1.29
40	0.062	62	14285	3589	15435	1.14
45	0.067	64	10891	2585	10956	1.05
50	0.049	54	8259	1798	7884	0.98
55	0.032	40	5897	1356	6187	0.99
60+	0.050	487	16890	1119		
Z(60)	16.6	16.6				
D(45+)	645					
D(10+)	1086					

Source: Computed from Death Registration data 1999 & Population Census, 1989 & 1999

Table 3.17: Estimation of Completeness Bungoma-Males For A=55
Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x(x)$	$N^*(x)$	$_5\bar{N}^*_x(x)$	$_{10}N^*_{x-5}(x)/ {_{10}N_{x-5}(x)}$
0	0.0394	579	84160	25223.5	113525.3	
5	0.0367	100	67074	20186.7	92243.9	1.36
10	0.0484	66	64160	16710.9	74431.6	1.27
15	0.0491	50	52283	13061.7	58089.7	1.14
20	0.0563	55	36336	10174.2	44510.7	1.16
25	0.0474	72	26324	7630.1	33966.1	1.25
30	0.0443	57	20524	5956.3	26696.2	1.29
35	0.0640	79	18204	4722.1	20211.3	1.21
40	0.0616	62	14285	3362.4	14451.0	1.07
45	0.0667	64	10891	2418.0	10240.5	0.98
50	0.0494	54	8259	1678.2	7352.5	0.92
55+	0.0451	527	22787	1262.8		
Z(55)	19.4					
D(45+)	645					
D(10+)	1086					

Source: Computed from Death Registration data 1999 & Population Census, 1989 & 1999

Table 3.18 Estimation of Completeness Bungoma-Males For A=50
Based on Bennett-Horiuchi method

Age	$_5r_x$	$_5D_x$	$_5N_x(x)$	$N^*(x)$	$_5\bar{N}^*_x(x)$	$_{10}N^*_{x-5}(x)/ {_{10}N_{x-5}(x)}$
0	0.0394	579	84160	25394.7	114305.1	
5	0.0367	100	67074	20327.3	92888.2	1.37
10	0.0484	66	64160	16828.0	74954.0	1.28
15	0.0491	50	52283	13153.6	58499.2	1.15
20	0.0563	55	36336	10246.1	44826.1	1.17
25	0.0474	72	26324	7684.4	34208.8	1.26
30	0.0443	57	20524	5999.1	26889.0	1.30
35	0.0640	79	18204	4756.4	20359.4	1.22
40	0.0616	62	14285	3387.3	14559.1	1.07
45	0.0667	64	10891	2436.3	10319.1	0.99
50+	0.0462	581	31046	1691.3		
Z(50)	23.1					
D(45+)	645					
D(10+)	1086					

Source: Computed from Death Registration data 1999 & Population Census, 1989 & 1999

Appendix 4

Table 4.1 Life Table Nairobi Males Based on the Brass Method

Age	Recorded pop. Males	$_5D_x$	Adjusted $_nD_x$	Adjusted $_nM_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	148574	2186	3944		0.1230	0.8770	1000	4692.5	50058.7	50.1
5	97322	226	408	0.0042	0.0207	0.9793	877	4339.6	45366.2	51.7
10	80587	108	195	0.0024	0.0120	0.9880	859	4268.3	41026.6	47.8
15	91437	188	339	0.0037	0.0184	0.9816	849	4203.5	36758.3	43.3
20	168926	385	695	0.0041	0.0203	0.9797	833	4122.2	32554.8	39.1
25	170343	652	1176	0.0069	0.0339	0.9661	816	4010.6	28432.6	34.8
30	123360	797	1438	0.0117	0.0566	0.9434	788	3829.8	24422.0	31.0
35	88712	782	1411	0.0159	0.0765	0.9235	744	3576.0	20592.3	27.7
40	59224	629	1135	0.0192	0.0914	0.9086	687	3276.9	17016.3	24.8
45	42817	548	989	0.0231	0.1091	0.8909	624	2949.6	13739.4	22.0
50	30961	395	713	0.0230	0.1088	0.8912	556	2628.2	10789.8	19.4
55	13963	277	500	0.0358	0.1642	0.8358	495	2273.5	8161.6	16.5
60	8829	262	473	0.0535	0.2361	0.7639	414	1825.8	5888.1	14.2
65	4697	179	323	0.0687	0.2933	0.7067	316	1349.5	4062.3	12.8
70	3247	174	314	0.0967	0.3893	0.6107	224	900.0	2712.8	12.1
75+	4375	593	1070	0.2445	0.7588	0.2412	137	558.2	1812.8	13.3

Source: Computed from Death Registration Data & Population Census, 1999

Table 4.2 Life Table Nairobi Females Based on the Brass Method

Age	Recorded Pop.females	$_5D_x$	Adjusted $_nD_x$	Adjusted $_nM_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	142896	1822	1330		0.1200	0.8800	1000	4700	55293	55.3
5	98165	195	142	0.0015	0.0072	0.9928	880	4389	50593	57.5
10	91473	120	88	0.0010	0.0048	0.9952	876	4364	46203	52.8
15	124129	229	167	0.0013	0.0067	0.9933	870	4327	41839	48.1
20	169108	492	359	0.0021	0.0106	0.9894	861	4262	37513	43.6
25	129226	693	506	0.0039	0.0194	0.9806	844	4159	33251	39.4
30	77397	620	453	0.0058	0.0288	0.9712	820	4031	29091	35.5
35	53277	490	358	0.0067	0.0330	0.9670	793	3889	25060	31.6
40	31866	335	245	0.0077	0.0376	0.9624	763	3729	21172	27.8
45	21706	271	198	0.0091	0.0446	0.9554	729	3549	17442	23.9
50	14318	210	153	0.0107	0.0521	0.9479	691	3331	13893	20.1
55	7351	149	109	0.0148	0.0713	0.9287	642	3045	10562	16.5
60	5338	156	114	0.0213	0.1013	0.8987	577	2702	7517	13.0
65	3236	119	87	0.0268	0.1258	0.8742	504	2319	4816	9.6
70	2948	140	102	0.0347	0.1595	0.8405	424	1783	2496	5.9
75+	4731	487	356	0.0751	0.3163	0.6837	290	713	713	2.5

Source: Computed from Death Registration Data & Population Census, 1999

Table4.3 Life Table Nyeri Males Based on the Brass Method

Age	Recorded Pop. Males	$_5D_x$	Adjusted $_nD_x$	Adjusted $_nM_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	41250	270	213		0.0570	0.9430	1000	4858	66445	66.4
5	38371	31	24	0.0006	0.0032	0.9968	943	4707	61588	65.3
10	46218	15	12	0.0003	0.0013	0.9987	940	4697	56880	60.5
15	40832	27	21	0.0005	0.0026	0.9974	939	4688	52183	55.6
20	30646	51	40	0.0013	0.0066	0.9934	936	4666	47496	50.7
25	24940	56	44	0.0018	0.0088	0.9912	930	4631	42829	46.0
30	21172	102	81	0.0038	0.0189	0.9811	922	4567	38199	41.4
35	17449	102	81	0.0046	0.0228	0.9772	905	4471	33632	37.2
40	11202	69	55	0.0049	0.0240	0.9760	884	4367	29161	33.0
45	10074	74	58	0.0058	0.0286	0.9714	863	4252	24794	28.7
50	10050	84	66	0.0066	0.0325	0.9675	838	4122	20542	24.5
55	6514	57	45	0.0069	0.0340	0.9660	811	3985	16420	20.3
60	5868	78	62	0.0105	0.0512	0.9488	783	3816	12435	15.9
65	4067	69	55	0.0134	0.0648	0.9352	743	3596	8619	11.6
70	3989	114	90	0.0226	0.1069	0.8931	695	3289	5023	7.2
75+	6601	318	251	0.0381	0.1738	0.8262	621	1734	1734	2.8

Source: Computed from Death Registration Data & Population Census, 1999

Table 4.4 Life Table Nyeri Females Based on the Brass Method

Age	Recorded Pop. females	$_5D_x$	Adjusted $_nD_x$	Adjusted $_nM_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	39964	214	229		0.0650	0.9350	1000	4838	66374.4	66.4
5	37704	23	25	0.0007	0.0033	0.9967	935	4667	61536.9	65.8
10	45505	9	10	0.0002	0.0011	0.9989	932	4657	56869.5	61.0
15	39708	24	26	0.0006	0.0032	0.9968	931	4647	52212.2	56.1
20	33051	51	55	0.0017	0.0082	0.9918	928	4621	47564.9	51.3
25	28383	76	81	0.0029	0.0142	0.9858	920	4569	42944.2	46.7
30	23588	98	105	0.0044	0.0220	0.9780	907	4486	38375.2	42.3
35	19339	90	96	0.0050	0.0246	0.9754	887	4382	33888.9	38.2
40	12424	44	47	0.0038	0.0188	0.9812	865	4287	29506.9	34.1
45	11555	49	52	0.0045	0.0224	0.9776	849	4199	25220.2	29.7
50	11042	52	56	0.0050	0.0249	0.9751	830	4099	21021.6	25.3
55	7895	39	42	0.0053	0.0261	0.9739	810	3995	16922.3	20.9
60	7169	61	65	0.0091	0.0445	0.9555	788	3854	12927.5	16.4
65	5108	41	44	0.0086	0.0420	0.9580	753	3687	9073.2	12.0
70	5060	67	72	0.0142	0.0684	0.9316	722	3485	5385.7	7.5
75+	9180	349	373	0.0407	0.1846	0.8154	672	1901	1900.9	2.8

Source: Computed from Death Registration Data & Population Census, 1999

Table 4.5 Estimation of e(75) Nairobi Based on Bennett-Horiuchi method

Age	Male-89	Male-99	$_5r_x$	$\sum {_5r_x}$	2.5*($_5r_x$)	Exp (5*$\sum {_5r_x}$ +2.5*($_5r_x$))	$_5D_x$	c*B*$_5d_x$	N(x)
0	88825	148574	0.0514				2186		67062
5	65277	97322	0.0399	0.0514	0.0998	1.4291	262	374	49931
10	49676	80587	0.0484	0.0914	0.1210	1.7822	108	192	40655
15	55784	91437	0.0494	0.1398	0.1235	2.2758	188	428	31824
20	118153	168926	0.0357	0.1892	0.0894	2.8158	385	1084	24691
25	120344	170343	0.0347	0.2249	0.0869	3.3585	652	2190	20297
30	80959	123360	0.0421	0.2597	0.1053	4.0700	797	3244	16463
35	57589	88712	0.0432	0.3018	0.1080	5.0377	782	3940	12619
40	41910	59224	0.0346	0.3450	0.0865	6.1192	629	3849	9465
45	27530	42817	0.0442	0.3796	0.1104	7.4506	548	4083	7386
50	19173	30961	0.0479	0.4237	0.1198	9.3793	395	3705	5432
55	9898	13963	0.0344	0.4717	0.0860	11.5229	277	3192	3924
60	5392	8829	0.0493	0.5061	0.1233	14.2056	262	3722	3049
65	3136	4697	0.0404	0.5554	0.1010	17.7771	179	3182	2152
70	1657	3247	0.0673	0.5958	0.1682	23.2682	174	4049	1596
75+	2164	4375	0.0704	0.6631	0.1760	32.8271	593	19466	993
30d10	14926								
20d40	18550								
Ratio	0.80	e(75)=7.75							

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.6 Life Table Nairobi Males Based on Bennett-Horiuchi method

Age	$_np_x$	$_nq_x$	$_nd_x$	l_x	$_5L_x$	T_x	e_x
0	0.8770	0.1230	123	1000	4693	55852	55.9
5	0.9942	0.0058	5	877	4372	51160	58.3
10	0.9970	0.0030	3	872	4353	46788	53.7
15	0.9933	0.0067	6	869	4332	42434	48.8
20	0.9830	0.0170	15	863	4281	38102	44.1
25	0.9650	0.0350	30	849	4170	33822	39.8
30	0.9462	0.0538	44	819	3985	29652	36.2
35	0.9310	0.0690	53	775	3741	25667	33.1
40	0.9276	0.0724	52	722	3477	21926	30.4
45	0.9172	0.0828	55	669	3208	18449	27.6
50	0.9181	0.0819	50	614	2943	15241	24.8
55	0.9231	0.0769	43	564	2709	12298	21.8
60	0.9029	0.0971	51	520	2475	9589	18.4
65	0.9080	0.0920	43	470	2240	7114	15.1
70	0.8711	0.1289	55	426	1995	4874	11.4
75+	0.0000	1.0000	371	371	2879	2879	7.8

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.7 Estimation of e(75) Nairobi Females Based on Bennett-Horiuchi method

Age	Female-89	Female-99	$_5r_x$	$\sum_5r_x$	2.5*($_5r_x$)	Exp (5*$\sum_5r_x$ +2.5*($_5r_x$))	$_5D_x$	c*B*$_5d_x$	N(x)
0	87102	142896	0.0495				1822		122213
5	67734	98165	0.0371	0.0495	0.0928	1.41	195	274	93806
10	56771	91473	0.0477	0.0866	0.1193	1.74	120	208	77744
15	71978	124129	0.0545	0.1343	0.1362	2.24	229	514	61140
20	94582	169108	0.0581	0.1888	0.1453	2.97	492	1462	46358
25	74949	129226	0.0545	0.2469	0.1362	3.94	693	2729	34244
30	41606	77397	0.0621	0.3014	0.1552	5.27	620	3268	25474
35	28419	53277	0.0628	0.3635	0.1571	7.20	490	3529	18146
40	17211	31866	0.0616	0.4263	0.1540	9.83	335	3293	12835
45	10457	21706	0.0730	0.4879	0.1826	13.76	271	3730	9145
50	6669	14318	0.0764	0.5609	0.1910	20.00	210	4200	6122
55	3881	7351	0.0639	0.6373	0.1597	28.40	149	4232	4005
60	3181	5338	0.0518	0.7012	0.1294	37.92	156	5916	2783
65	1924	3236	0.0520	0.7530	0.1300	49.15	119	5849	2011
70	1378	2948	0.0760	0.8050	0.1901	67.69	140	9477	1446
75+	2477	4731	0.0647	0.8810	0.1618	96.24	487	46871	873
30d10	15004								
20d40	21371								
Ratio	0.7021	e(75)=9.66							

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.8 Life Table Nairobi Females Based on Bennett-Horiuchi method

Age	$_np_x$	$_nq_x$	$_5d_x$	l_x	$_5L_x$	T_x	e_x
0	0.9832	0.1200	120	1000	4700	80880	80.9
5	0.9977	0.0023	2	880	4695	76180	86.6
10	0.9983	0.0017	2	998	4991	71485	71.6
15	0.9957	0.0043	4	998	4985	66495	66.6
20	0.9878	0.0122	12	996	4959	61510	61.8
25	0.9769	0.0231	23	988	4912	56551	57.2
30	0.9717	0.0283	28	977	4874	51638	52.8
35	0.9685	0.0315	31	972	4854	46764	48.1
40	0.9697	0.0303	29	969	4850	41910	43.2
45	0.9646	0.0354	34	971	4841	37060	38.2
50	0.9587	0.0413	40	966	4814	32220	33.4
55	0.9565	0.0435	42	960	4796	27405	28.5
60	0.9365	0.0635	61	958	4744	22609	23.6
65	0.9329	0.0671	63	939	4690	17866	19.0
70	0.8835	0.1165	109	937	4570	13176	14.1
75+	0.0000	1.0000	891	891	8606	8606	9.7

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.9 Estimation of e(75) Nyeri Males Based on Bennett-Horiuchi method

Age	Male-89	Male-99	$_5r_x$	$\sum_5r_x$	$2.5*(_5r_x)$	Exp $(5*\sum_5r_x + 2.5*(_5r_x))$	$_5D_x$	$c*B*_5d_x$	N(x)
0	46249	41250	-0.0114				270		3559
5	48985	38371	-0.0244	-0.0114	-0.0611	0.8885	31	28	3490
10	45542	46218	0.0015	-0.0359	0.0037	0.8389	15	13	3911
15	36698	40832	0.0107	-0.0344	0.0267	0.8648	27	23	3867
20	26561	30646	0.0143	-0.0237	0.0358	0.9205	51	47	3640
25	20017	24940	0.0220	-0.0094	0.0550	1.0080	56	56	3339
30	12853	21172	0.0499	0.0126	0.1248	1.2065	102	123	2939
35	11162	17449	0.0447	0.0625	0.1117	1.5283	102	156	2199
40	10111	11202	0.0102	0.1072	0.0256	1.7532	69	121	1668
45	7860	10074	0.0248	0.1174	0.0620	1.9139	74	142	1517
50	6637	10050	0.0415	0.1422	0.1037	2.2589	84	190	1271
55	4800	6514	0.0305	0.1837	0.0763	2.7046	57	154	957
60	4516	5868	0.0262	0.2143	0.0655	3.1167	78	243	768
65	3792	4067	0.0070	0.2404	0.0175	3.3863	69	234	601
70	2829	3989	0.0344	0.2474	0.0859	3.7552	114	428	512
75+	6303	6601	0.0046	0.2818	0.0115	4.1396	318	1316	327
30d10	539								
20d40	503								
30d10/20d40	1.07	e(75)=6.41							

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.10 Life Table Nyeri Males Based on Bennett-Horiuchi method

Age	$_np_x$	$_nq_x$	$_nd_x$	l_x	$_5L_x$	T_x	e_x
0	0.9430	0.0570	57	1000	4857.5	61637.5	61.6
5	0.9916	0.0084	8	943	4695.3	56780.0	60.2
10	0.9962	0.0038	4	935	4666.6	52084.7	55.7
15	0.9928	0.0072	7	932	4640.9	47418.1	50.9
20	0.9855	0.0145	13	925	4590.7	42777.2	46.3
25	0.9823	0.0177	16	911	4516.7	38186.5	41.9
30	0.9607	0.0393	35	895	4388.4	33669.8	37.6
35	0.9482	0.0518	45	860	4189.0	29281.4	34.0
40	0.9576	0.0424	35	816	3991.0	25092.4	30.8
45	0.9481	0.0519	41	781	3803.3	21101.4	27.0
50	0.9267	0.0733	54	740	3566.4	17298.1	23.4
55	0.9357	0.0643	44	686	3320.5	13731.7	20.0
60	0.8917	0.1083	70	642	3036.4	10411.3	16.2
65	0.8833	0.1167	67	573	2695.6	7374.8	12.9
70	0.7579	0.2421	122	506	2222.5	4679.3	9.3
75+	0.0000	1.0000	383	383	2456.8	2456.8	6.4

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.11 Estimation of e(75) Nyeri Females Based on Bennett-Horiuchi method

Age	Female-89	female-99	${}_5r_x$	$\sum {}_5r_x$	$2.5*({}_5r_x)$	Exp ($5*\sum {}_5r_x$ $+2.5*({}_5r_x)$)	${}_5D_x$	$c*B*_5$ d_x	N(x)
0	45150	39964	-0.0122				214		8391
5	48224	37704	-0.0246	-0.0122	-0.0615	0.8847	23	20	8698
10	44949	45505	0.0012	-0.0368	0.0031	0.8345	9	8	9813
15	36568	39708	0.0082	-0.0356	0.0206	0.8544	24	21	9743
20	30665	33051	0.0075	-0.0273	0.0187	0.8887	51	45	9327
25	23486	28383	0.0189	-0.0198	0.0473	0.9494	76	72	8934
30	1417	23588	0.2812	-0.0009	0.7030	2.0107	98	197	8054
35	12632	19339	0.0426	0.2803	0.1065	4.5177	90	407	1925
40	11395	12424	0.0086	0.3229	0.0216	5.1351	44	226	1475
45	9715	11555	0.0173	0.3315	0.0434	5.4798	49	269	1369
50	7858	11042	0.0340	0.3489	0.0850	6.2307	52	324	1209
55	5475	7895	0.0366	0.3829	0.0915	7.4338	39	290	972
60	5852	7169	0.0203	0.4195	0.0507	8.5702	61	523	774
65	4316	5108	0.0168	0.4398	0.0421	9.4042	41	386	641
70	3582	5060	0.0345	0.4567	0.0864	10.6935	67	716	550
75+	7981	9180	0.0140	0.4912	0.0350	12.0732	349	4214	401.5
30d10	975								
20d40	1631								
30d10/20d40	0.60	10.23							

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.12 Life Table Nyeri females Based on Bennett-Horiuchi method

Age	${}_np_x$	${}_nq_x$	${}_nd_x$	l_x	${}_5L_x$	T_x	e_x
0	0.9350	0.0650	65	1000	4837.5	67743.6	67.7
5	0.9975	0.0025	2	935	4669.2	62906.1	67.3
10	0.9991	0.0009	1	933	4661.2	58236.9	62.4
15	0.9975	0.0025	2	932	4653.2	53575.6	57.5
20	0.9944	0.0056	5	929	4634.5	48922.4	52.6
25	0.9911	0.0089	8	924	4600.9	44287.9	47.9
30	0.9754	0.0246	22	916	4524.1	39687.0	43.3
35	0.9481	0.0519	46	894	4351.8	35162.9	39.4
40	0.9696	0.0304	26	847	4171.3	30811.0	36.4
45	0.9627	0.0373	31	821	4030.2	26639.7	32.4
50	0.9532	0.0468	37	791	3861.1	22609.5	28.6
55	0.9561	0.0439	33	754	3685.9	18748.4	24.9
60	0.9172	0.0828	60	721	3454.0	15062.5	20.9
65	0.9334	0.0666	44	661	3194.8	11608.5	17.6
70	0.8674	0.1326	82	617	2880.2	8413.8	13.6
75+	0.0000	1.0000	535	535	5533.5	5533.5	10.3

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.13 estimation of e(75) Bungoma Females Based on Bennett-Horiuchi method

Age	Female-89	Female-99	$_5r_x$	$\sum_5r_x$	2.5*($_5r_x$)	Exp (5*$\sum_5r_x$ +2.5*($_5r_x$))	$_5D_x$	c*B*$_5d_x$	N(x)
0	57176	83414	0.038				495		29312
5	49993	67659	0.030	0.038	0.076	1.303	83	108	23826
10	40111	65606	0.049	0.068	0.123	1.589	51	81	20400
15	32423	53459	0.050	0.117	0.125	2.036	50	102	15906
20	24148	42157	0.056	0.167	0.139	2.652	50	133	12343
25	19691	30425	0.044	0.223	0.109	3.399	88	299	9299
30	14579	23554	0.048	0.266	0.120	4.273	56	239	7401
35	10846	20393	0.063	0.314	0.158	5.641	73	412	5771
40	8363	15729	0.063	0.378	0.158	7.735	59	456	4147
45	6546	12100	0.061	0.441	0.154	10.562	36	380	2973
50	5526	9240	0.051	0.502	0.129	14.005	37	518	2157
55	4718	6913	0.038	0.554	0.096	17.522	36	631	1637
60	3436	5914	0.054	0.592	0.136	22.081	36	795	1318
65	2773	4974	0.058	0.646	0.146	29.269	32	937	973
70	1986	3282	0.050	0.705	0.126	38.405	36	1383	699
75+	2936	5094	0.055	0.755	0.138	49.975	304	15192	512
30d10	1722								
20d40	2781								
30d10/10d40	0.62	e(75)=9.98							
N(75)	512								

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.14 Life Table Bungoma Females Based on Bennett-Horiuchi method

Age	$_np_x$	$_nq_x$	$_nd_x$	l_x	$_5L_x$	T_x	$e_{(x)}$
0	0.9040	0.0960	96	1000	4760	70826	70.8
5	0.9961	0.0039	4	904	4511	66066	73.1
10	0.9972	0.0028	3	900	4496	61555	68.4
15	0.9964	0.0036	3	898	4481	57059	63.5
20	0.9955	0.0045	4	895	4463	52577	58.8
25	0.9893	0.0107	10	891	4429	48114	54.0
30	0.9911	0.0089	8	881	4386	43685	49.6
35	0.9852	0.0148	13	873	4334	39299	45.0
40	0.9834	0.0166	14	860	4266	34965	40.6
45	0.9862	0.0138	12	846	4201	30699	36.3
50	0.9811	0.0189	16	834	4133	26498	31.8
55	0.9748	0.0252	21	819	4042	22365	27.3
60	0.9684	0.0316	25	798	3927	18323	23.0
65	0.9627	0.0373	29	773	3792	14396	18.6
70	0.9409	0.0591	44	744	3610	10604	14.3
75+	0.0000	1.0000	700	700	6993	6993	10.0

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

Table 4.15 Life Table Females Bungoma Based on Brass Method

Age	Recorded		Adjusted	Adjusted						
	Pop. Females	$_5D_x$	$_nD_x$	$_nM_x$	$_nq_x$	$_np_x$	l_x	$_5L_x$	T_x	e_x
0	83414	495	495		0.0960	0.9040	1000	4760	66979	67.0
5	67659	83	109	0.0016	0.0040	0.9984	904	4511	62219	68.8
10	65606	51	67	0.0010	0.0025	0.9990	900	4496	57708	64.1
15	53459	50	66	0.0012	0.0031	0.9988	898	4484	53212	59.3
20	42157	50	66	0.0016	0.0039	0.9984	895	4468	48728	54.4
25	30425	88	116	0.0038	0.0094	0.9962	892	4438	44260	49.6
30	23554	56	74	0.0031	0.0077	0.9969	883	4400	39822	45.1
35	20393	73	96	0.0047	0.0116	0.9953	877	4358	35422	40.4
40	15729	59	77	0.0049	0.0122	0.9951	866	4306	31064	35.9
45	12100	36	47	0.0039	0.0097	0.9961	856	4259	26758	31.3
50	9240	37	49	0.0053	0.0130	0.9947	848	4211	22499	26.5
55	6913	36	47	0.0068	0.0168	0.9932	837	4148	18289	21.9
60	5914	36	47	0.0080	0.0196	0.9920	823	4073	14141	17.2
65	4974	32	42	0.0084	0.0207	0.9916	806	3991	10068	12.5
70	3282	36	47	0.0144	0.0348	0.9856	790	3880	6077	7.7
75+	5094	304	399	0.0784	0.1638	0.9216	762	2197	2197	2.9

Source: Computed from Death Registration Data, 1999 & Population Census, 1989 & 1999

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