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Under-five Mortality Trends in Africa:

Reconstruction from Demographic Sample Surveys

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ABSTRACT

The study presents a reconstruction of under-five mortality trends derived from data provided by the Demographic and Health Surveys (DHS) and World Fertility Surveys (WFS) in sub-Saharan Africa from 1950 to 2000. Death rates were first calculated by single years for each of the 64 surveys available. When several surveys were available for the same country, they were combined for each of the overlapping years. Then the series was analyzed to identify periods of monotonic trends, whether they were declining, steady, or increasing. Changes in trends were tested using a linear logistic model. All calculations were done at the national level and by urban-rural residence. Among the 33 countries studied, which account for some 80 percent of the sub-Saharan population, only eight had monotonic or quasi-monotonic mortality trends, which indicate a smooth health transition. Another eight countries had periods when mortality rose significantly for a variety of reasons. In at least eight other countries mortality increased through 1985-90—the most recent period covered in the study—as a result of increasing levels of AIDS mortality. Reconstructed levels and trends are compared with other estimates made by international organizations. These estimates are usually based on indirect methods.

Results indicate that in sub-Saharan Africa, progress was made in the health transition during the second half of the twentieth century. However, improvement was slower than expected, with an average decline in mortality of -1.7 percent per year. The transition was not smooth in more than half of the countries, and cases of reversals in mortality trends occur that appear to be linked to political, economic, and epidemiological crises, particularly the HIV/AIDS pandemic.

Key words: under-five mortality, mortality trends, health transition, HIV/AIDS mortality, political crises, economic crises, emerging diseases, demographic impact, sub-Saharan Africa.

INTRODUCTION

The steady decline in mortality called the "health transition" has been one of the most salient features of demographic change in the twentieth century, and has had numerous economic and social consequences. The transition started in the second part of the nineteenth century in Western Europe and in North America, South America, and the Pacific countries where Europeans settled. This major change spread rapidly to most of the world, and by 1950 data showed that a steady decline in mortality and an increase in life expectancy had occurred worldwide since 1900 (Stolnitz, 1955; Stolnitz, 1965). Data from the second half of the twentieth century confirmed these trends, and until the sudden emergence of HIV/AIDS, these trends were expected to continue in the pattern of the most advanced countries, such as Japan.

The steady decline in mortality occurred with the emergence of modern states, and with the development of modern public health policies based on biomedical knowledge and the theory that disease is caused by germs. The decline also took place during a time of steady economic growth and major improvements in nutrition, housing, and living conditions. Modern public health practices, which developed in the second half of the nineteenth century in Western Europe and the United States, were applied within a few decades around the world by independent states and colonial powers. Among the first benefits were improvements in water and sanitation, hygiene, and child feeding practices, and the development of vaccinations. Further developments included the production of efficient medicines (particularly antibiotics and antimalarial drugs) and a variety of preventive and curative practices. The result was a dramatic decline in mortality, especially among infants, young children, and young adults (including mothers), primarily because of the decline in deaths due to infectious and parasitic diseases (Preston, 1976; Preston, 1980; McKeown, 1976).

Sub-Saharan countries began the health transition later than other countries. Although much change has occurred there since 1930, most countries still have relatively low levels of life expectancy and high levels of infant and child mortality. To fairly judge the health transition in Africa, it is appropriate to consider trends rather than simply current mortality indicators. In countries where the health transition started later, a relatively high level of under-five mortality during a period of steady mortality decline could still indicate a favorable health transition despite the apparent lack of change. However, where mortality trends are increasing, a relatively low level of under-five mortality could hide a negative change. It therefore is more useful to document mortality trends to understand the status of the health transition in Africa, and to identify gaps where further action is needed. This approach is particularly important for under-five mortality, the main target of public health policies and the most common indicator of levels of mortality.

Comprehensive registration data, the best source for assessing mortality trends, are currently not available in sub-Saharan Africa. To assess trends in mortality among young children, researchers rely on demographic sample surveys or other sources such as mortality data collected in censuses (United Nations, 1982; Brass et al., 1968; Feachem and Jamison, 1991; Mandjale, 1985; van de Walle, et al., 1988). A synthesis of indirect mortality estimates in Africa was conducted by the World Bank for the period before 1985. It revealed a steady decline in mortality (Hill, 1991; Hill and Hill, 1988). However, this synthesis suffers from the lack of precision of indirect methods to estimate trends. A more recent analysis was conducted by the World Health Organization (WHO) using direct and indirect estimates, and reconstructing trends by five-year periods from 1955-59 to 1995-99 (Ahmad, Lopez, and

Inoue, 2000). This compendium made better use of all available data, in particular direct estimates provided by DHS surveys. However, it covers five-year periods, which provide reasonable estimates of mortality levels and major trends, but often obscure the specific periods when changes in mortality trends occur. Precise knowledge of the date of reversals in mortality trends is important to understand the causation of the changes.

The aim of this study is to provide new estimates of under-five mortality trends in African countries with data from demographic sample surveys. The main rationale of this analysis is to identify periods of monotonic change and the precise times that trend changes occurred. This study was a prerequisite for a larger study of the determinants of reversals in mortality trends in sub-Saharan Africa currently being conducted by the authors. As will be described later in this report, periods of increasing mortality can be attributed to a variety of situations: political crises, economic crises, and epidemiological crises or emerging diseases. Special attention is devoted in this report to the possible impact of pediatric AIDS since 1985.

The methods used to reconstruct under-five mortality trends, to test changing slopes in mortality trends, and to examine the main results by country are described below. There are separate estimates by urban and rural residence. The appendix presents figures for each country, with brief descriptions of the determinants that are likely to explain changes in mortality trends. The full analysis will be published in a separate book.

DATA AND METHODS

To reconstruct mortality trends, data from the Demographic and Health Surveys and the World Fertility Survey were used. Data from both projects came from the collection of maternity histories from a representative sample of women of reproductive age (15-49 years). Maternity histories allowed the reconstruction of deaths among children born to women interviewed in the survey. On average, the mean number of women interviewed per survey was about 6,500, the mean number of births was 21,000, and the mean number of deaths was 4,000. Full maternity histories at the time of interviews included the date of birth and the age at death (when applicable) for each live birth. Date of birth was given by month and year, with no missing values in the standard recoded files. Age at death was provided in days for neonates, in months for young children, and in years for older children. Age at death included a few missing cases. These data allowed the computation of period death rates by month. Only under-five mortality was considered in this study.

A total of 56 DHS surveys and 10 WFS surveys were used, covering 32 sub-Saharan countries. These countries constitute about 70 percent of all African countries and 80 percent of the total population of sub-Saharan Africa and Madagascar, not including the small African islands (including Cape Verde, São Tomé and Principe, Mauritius, the Seychelles, Mayotte, Reunion, and Saint Helen). A Multiple Indicator Cluster Survey (MICS) was included to cover Angola, which had no DHS or WFS surveys. The MICS survey is based on a somewhat different methodology: only the birth histories of the last three pregnancies were included. The list of countries and surveys included in this study is presented in the appendix.

Maternity history data represent a biased sample of births and deaths in the years before the survey. Only births to women age 15-19 are considered, thus leaving out births that occurred previously among women now over age 50, which accounts for roughly half of the births in the 35 years before the survey. In the few years before the survey the biases are minimal, because older women have few births. However, when considering births more than 20 years before the survey, the biases become more prominent because the sample is more skewed, and the proportion of births to very young women increases. This phenomenon tends to result in overestimation of the level of mortality in earlier periods. Second, births to women who died before the survey are not counted. This omission tends to underestimate the mortality of young children because of the correlation between deaths of mothers and their children, that is, higher mortality among orphans. Third, there may be recall errors when recording births that occurred many years ago among women with high parity. In practice, these biases (positive and negative) tended to counterbalance each other. After many trials, it was decided to keep all the information available; that is, to not discount births that occurred more than 20 years before the survey. Of course, the sample size determines the confidence intervals of the point estimates and the slopes. In particular, for periods long before the survey, estimates are based on a small number of deaths and have wide confidence intervals. Justification of this strategy was primarily empirical. In countries where several surveys were available, estimates for an earlier period of a later survey were not significantly different from estimates for the same period in earlier surveys.

Computation of yearly death rates

In the first step, age- and period-specific death rates were calculated. The period used in this step is the year according to the Gregorian calendar. In the case of Ethiopia, the Amharic calendar was converted into a Gregorian calendar. Only two age groups were

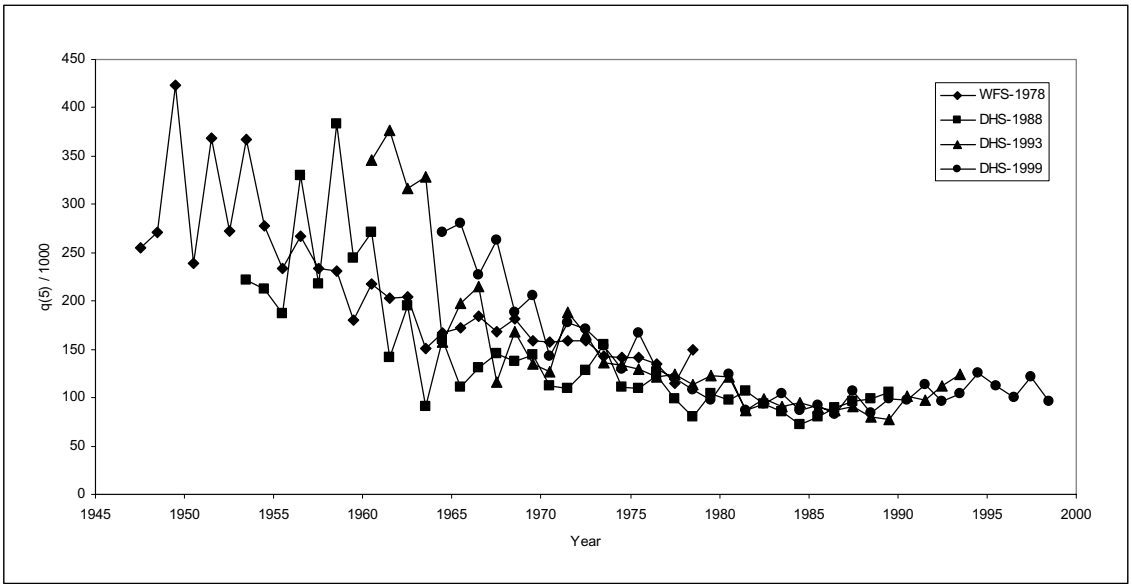
considered: 0-11 months and 12-59 months, to better specify the under-five death rate. Using each year of age between 0 and 4 years would have led to erratic estimates because of the small number of deaths after age two. For practical purposes of using the date function day, month, and year in computer programs, date of birth was considered to have occurred on the first day of the month. In cases of child death, the date of death was calculated by adding the age at death to the date of birth. When age at death was given in days, the calculation was direct. When the age at death was given in months, the date of death was calculated as the corresponding number of days (number of months = 365/12) plus 15 days (mid-month). When age at death was given in years, the date of death was calculated similarly, by adding the corresponding number of days (number of years/365 plus 183 days (mid-year). In rare cases when age at death was not known, it was imputed as the mean value for the other children, that is, 24 months. This procedure allowed the direct calculation of the person-months spent between birth and the date of the survey, by age and period. When the sample was stratified and weighted, the weights of the mother were applied to each birth. All the calculations were done in a program written for Dbase/FoxPro databases. The first step provided estimates of infant mortality rates (age 0-11 months) and child mortality rates (age 12-59 months) by calendar year. These were converted into under-five mortality rates (q(5)) by applying the standard formula: $q(5) = (1-{}_1q_0)*(1-{}_4q_1)$, with a mean duration until death of 0.33 for the infants and 1.35 for the children. These values were derived from the United Nations Model Life Tables, General Model for Developing Countries.

Figure 1 illustrates the results of these calculations for Kenya, a country with four surveys. Results show the general agreement among the four surveys (both in terms of level of mortality and trends) that allowed the four data sets to be combined. Values pertaining to the earliest years are strongly affected by random fluctuations, with the number of deaths for each year often less than 50. These fluctuations have no value for analysis; none of the differences in the various estimates for the same year are statistically significant. They all seemed to be due to random fluctuations. Furthermore, the data show a steady decline in mortality through 1984, followed by a sustained increase. This indicates a reversal in mortality trends, which is the focus of this study.

Aggregating the various surveys

In the second step, data from various surveys in the same country were aggregated. This was done by adding for the same year the person-months and the deaths, to recalculate the rates described above. Before this step, the surveys were examined graphically for compatibility. The surveys were found to be compatible in all the countries investigated, with the exception of Nigeria. This compatibility shows the high quality and high degree of consistency of WFS and DHS surveys. The aggregation of the data from several surveys was based on the principle of keeping and adding the number of deaths and the number of person-months observed in a given age group in a given year. This method allowed the calculation of the appropriate confidence intervals and the appropriate statistical tests for slopes. These procedures depend only on the number of deaths observed and the level of mortality.

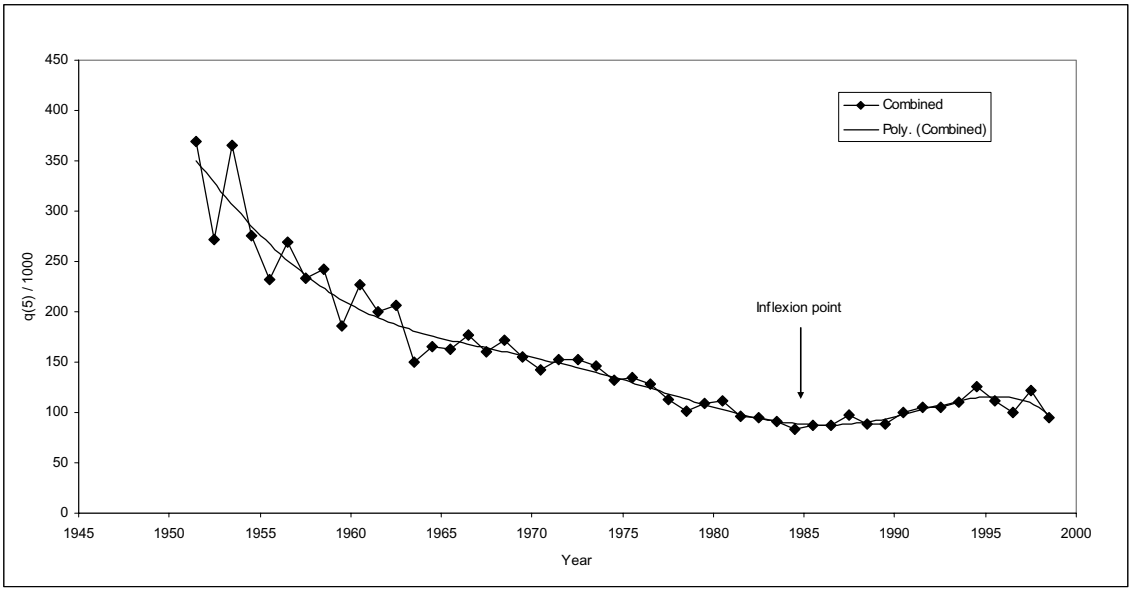
Figure 1: Annual under-five mortality rates by survey, Kenya



Search for monotonic periods and inflexion points

In the third step, the authors searched for monotonic periods of mortality change and inflexion points where a change in slope occurred. In a regular health transition, the rate at which death rates decline tends to be constant over long periods of time. For example, in France under-five mortality declined at a rate of about 5 percent per year between 1950 and 1999. The search for inflexion points was conducted graphically first, and then tested statistically. Graphically, a high-degree polynomial (degree 4 to 6) was fitted to the aggregated data to identify changing slopes. Once monotonic periods were identified, the slope was estimated, and a test was performed to verify whether the changing slope was significant (see section 2.5). Changing slopes resulting from erratic values in the earliest periods were discarded. In the example shown in Figure 2, two monotonic periods appear: a steady decline before 1984 and a steady increase thereafter. When compared with trends, differences with point estimates were not statistically significant, with the exception of two points: 1954 and 1964. Differences between observed data and trends were therefore interpreted as random fluctuations.

Figure 2: Aggregation of the four surveys and polynomial adjustment, Kenya



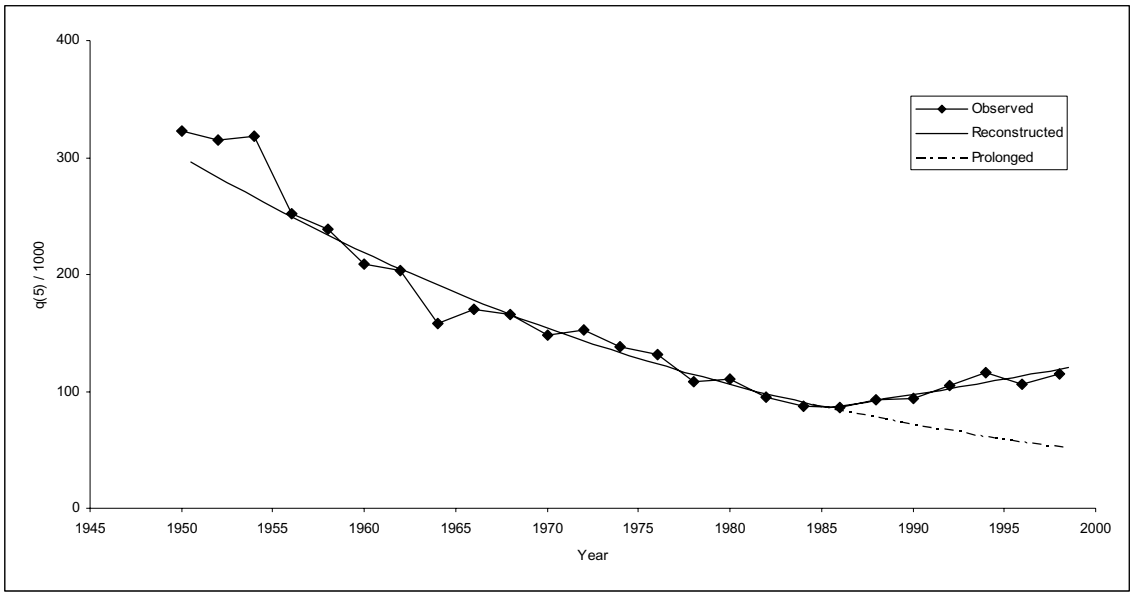
Estimations of under-five mortality by two-year periods

Annual data were used to maximize the precision of trends and inflexion points, which is important for understanding the determinants of trends. However, as seen above, annual data are affected by random fluctuations. To improve the presentation of the raw estimates, data were grouped by two-year periods for most of the estimates, and by five-year periods for the earliest dates. This was done by adding deaths and person-months. Estimates by two-year periods are more stable in countries with a large number of deaths, as in the case of Kenya (Figure 3).

Calculation of trends by monotonic period and testing changing trends

After monotonic periods were identified, trends could be formally calculated. This was done by considering the equivalence of period and cohort estimates and applying a Logit model. A period estimated of q(5) based on D(5) deaths was considered to apply to N(5) = D(5)/q(5) births in a theoretical cohort. Each period estimate in year (t) of under-five mortality q(t) could therefore be used to generate a sample of N(t) births, among which D(t) died. These samples were used to compute the slope of mortality decline, given the exact number of deaths observed each year in the combined sample. We used the linear logistic model (Logit model) in SPSS to calculate the slopes and the corresponding confidence intervals. Thereafter, we call "logistic slope" the slope of the Logit adjustment made on these data. The logistic slope provides a measure of the speed of the mortality decline, or the speed of the mortality increase, depending on the sign of the slope. This method also allowed the testing of changes in slopes between periods of monotonic change. This was done by using a T-test between the two slopes. Comparing the observed values to the predicted value by the Logit model also permitted the identification of periods of abnormally high or low mortality compared with trends. When the difference is statistically significant, the corresponding point appears as

Figure 3: Under-five mortality by two-year periods and Logit adjustment, Kenya



transparent on the figures. The Logit model also allowed the authors to prolong previous trends, and in case of reversal in mortality trends to compare the observed values with the expected value from earlier trends, that is, to compare the mortality crisis with the normal course of the health transition. Figure 3 shows two points of high value (1954) and low value (1974) in Kenya, which do not affect the interpretation of the trends. It also shows that according to previous trends (1950-84), mortality in 1998 was expected to be 52 per 1,000, whereas a much higher level was found (115 per 1,000) after the mortality increase. This provides a measure of the magnitude of mortality increase, which could be compared with the net effect of pediatric AIDS.

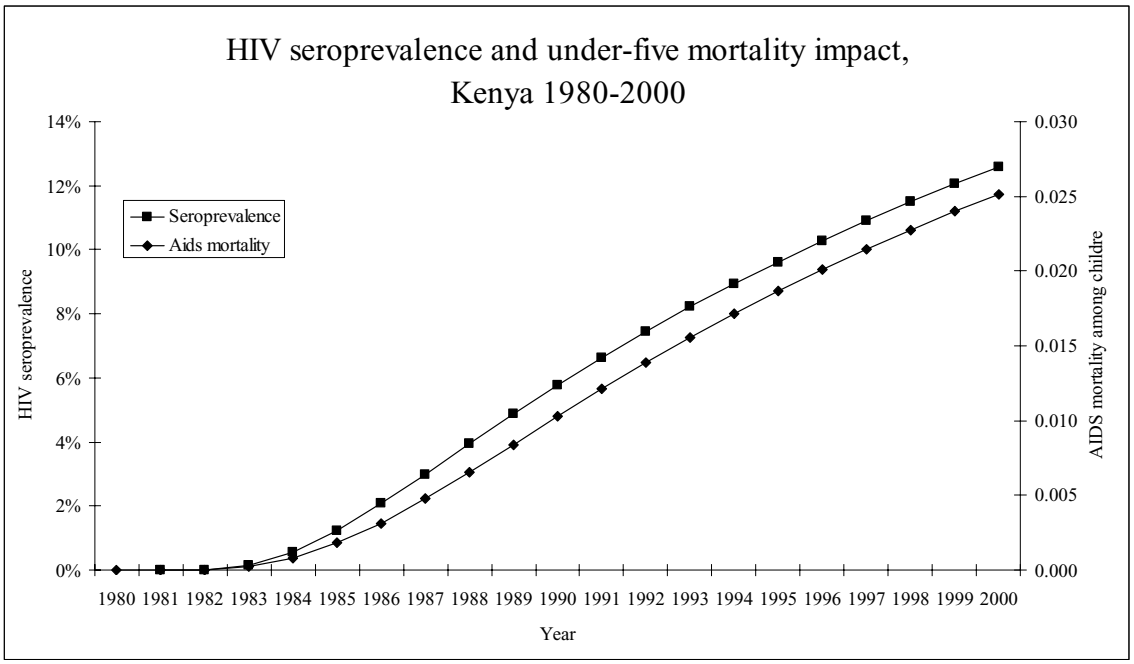
HIV seroprevalence and expected impact of pediatric AIDS

Pediatric AIDS has become a leading cause of mortality in many African countries. Pediatric AIDS causes as many deaths as all the other major causes of infant and child mortality combined. By itself it could cause a reversal in mortality trends in countries with high HIV seroprevalence among adult women, when other causes are held constant or in regular decline. It is therefore important to assess what the mortality trends would have been without pediatric AIDS in order to evaluate the course of the health transition in the absence of HIV. Pediatric AIDS comes almost entirely from the vertical transmission of the HIV virus from mother to child, during pregnancy, at the time of delivery, or through breastfeeding. HIV seroprevalence among pregnant women, the most commonly available source of information on HIV in Africa, is therefore an adequate indicator of pediatric AIDS mortality, assuming constant probabilities of vertical transmission and constant probabilities of death among HIV-infected children.

To estimate the net effect of pediatric AIDS on under-five mortality, we have reconstructed the dynamics of HIV seroprevalence among pregnant women in African countries. This was done using data provided by the AIDS database of the U.S. Bureau of Census, International Programs. For many countries, HIV seroprevalence estimates are

available for several years between 1980 and 2000. In only one case, South Africa, is the series complete for all years between 1990 and 2000. In other countries, only a few data points are available. The authors developed a model of the increase in seroprevalence based on the South African data. The model is simply a hyperbolic function of the Logit of the proportions of seropositive women. This model fit well with the South African case and with many other countries for which more than five points were available, and where seroprevalence increased steadily until the last point available before 2000. In two cases where the increase in seroprevalence was halted and even reversed (Uganda and Zaire), two curves were fit, one ascending (Logit-hyperbolic) and one descending (Logit-linear). These models were applied to all countries with HIV seroprevalence data for the period 1980-2000.

Figure 4: Estimation of pediatric AIDS mortality as a function of seroprevalence, Kenya

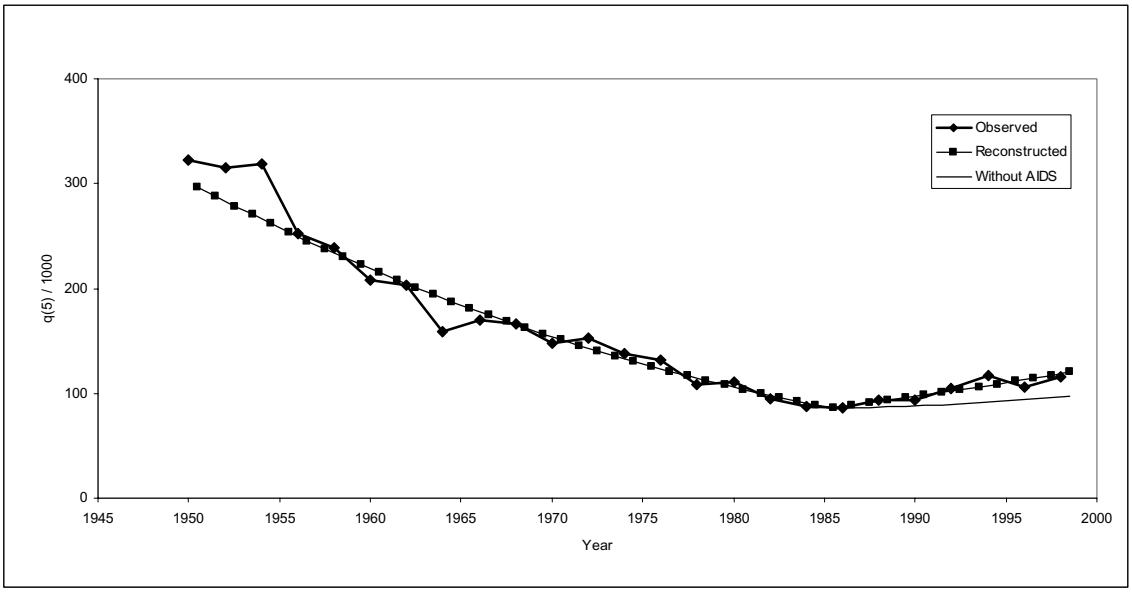


After the dynamics of the HIV epidemic among pregnant women is reconstructed, year by year, one can estimate the expected pediatric AIDS mortality. A constant vertical transmission of 25 percent was assumed, without modulating for the duration of breastfeeding. It was assumed that 30 percent of infected children were dying of HIV/AIDS each year between ages 0 and 5, in a life table framework, without taking into account the level of mortality in the country. These estimates could be refined when more data on AIDS mortality become available. The parameters taken correspond to the mean of various studies conducted in sub-Saharan Africa. Results show a close correlation between the dynamics of seroprevalence of AIDS among pregnant women and the net effect on under-five mortality. In the case of Kenya, where seroprevalence has increased steadily, the two curves are almost parallel (Figure 4). In the case of increasing-then-decreasing seroprevalence, as in Uganda, the effect on under-five mortality is diluted over a longer period, and somewhat smoothed by the cohort effects.

Trends without AIDS

To calculate mortality trends without AIDS, it was assumed that causes of death were additive and that mortality without AIDS was equal to total mortality minus the mortality attributable to pediatric AIDS. Figure 5 displays the net effect of HIV/AIDS for Kenya. In 1998, under-five mortality was estimated from trends at 120 per 1,000 and at 98 per 1,000 without AIDS. AIDS accounted for only part of the mortality increase after 1984, and even without AIDS a change occurred in mortality decline after 1984.

Figure 5: Estimation of under-five mortality trends without AIDS, Kenya

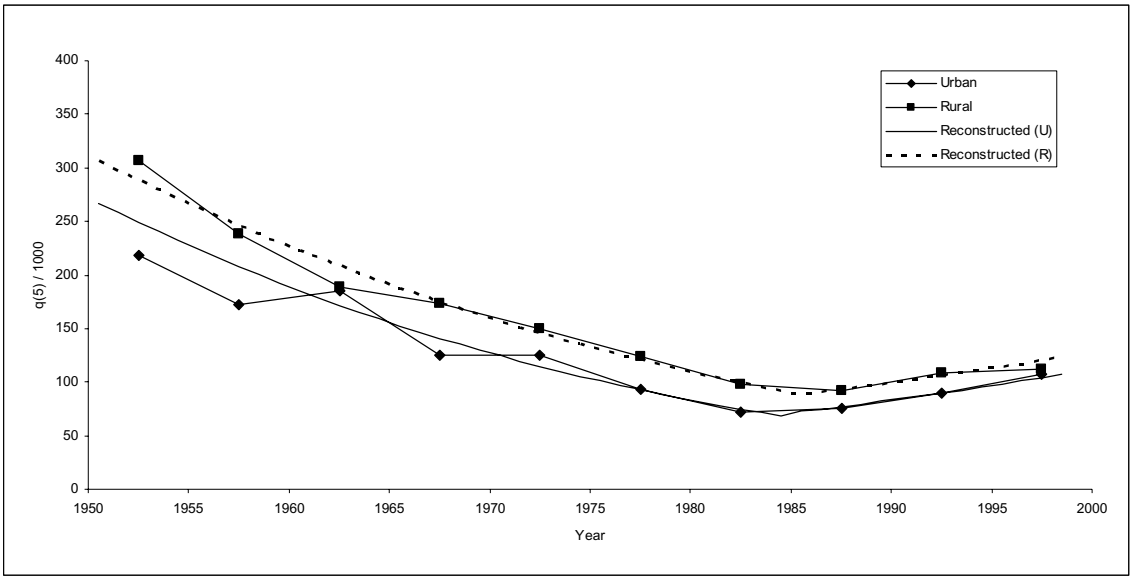


In some countries, data on HIV seroprevalence among pregnant women are of poor quality, and any assessment should be considered with caution. In other countries, HIV seroprevalence among pregnant women remained at a low level until 2000, and the net effect of pediatric AIDS is therefore small compared with all causes of mortality. When AIDS accounts for less than 10 percent of under-five mortality, the net effect of AIDS was not presented in the figures. Calculation of trends without pediatric AIDS was done in all countries with high HIV seroprevalence; that is, all countries in Eastern and Southern Africa, plus three countries in West Africa: Côte d'Ivoire, Mali, and Burkina Faso.

Comparison with other data sources

Our estimations of mortality trends, before correcting for pediatric AIDS, were compared with other data sources: the estimates based on indirect methods published by the World Bank (Hill, 1991); the estimates published by WHO (Ahmad, Lopez, and Inoue, 2000); the direct estimates provided by DHS data; and, in some cases, the Institut National de la Statistique et des Études Économiques (INSEE) surveys conducted in francophone countries in the 1960s and 1970s. These comparisons allowed the authors to validate the reconstruction and to measure the inaccuracy of other estimates, in particular indirect estimates.

Figure 6: Comparison with indirect estimates and other data, Kenya

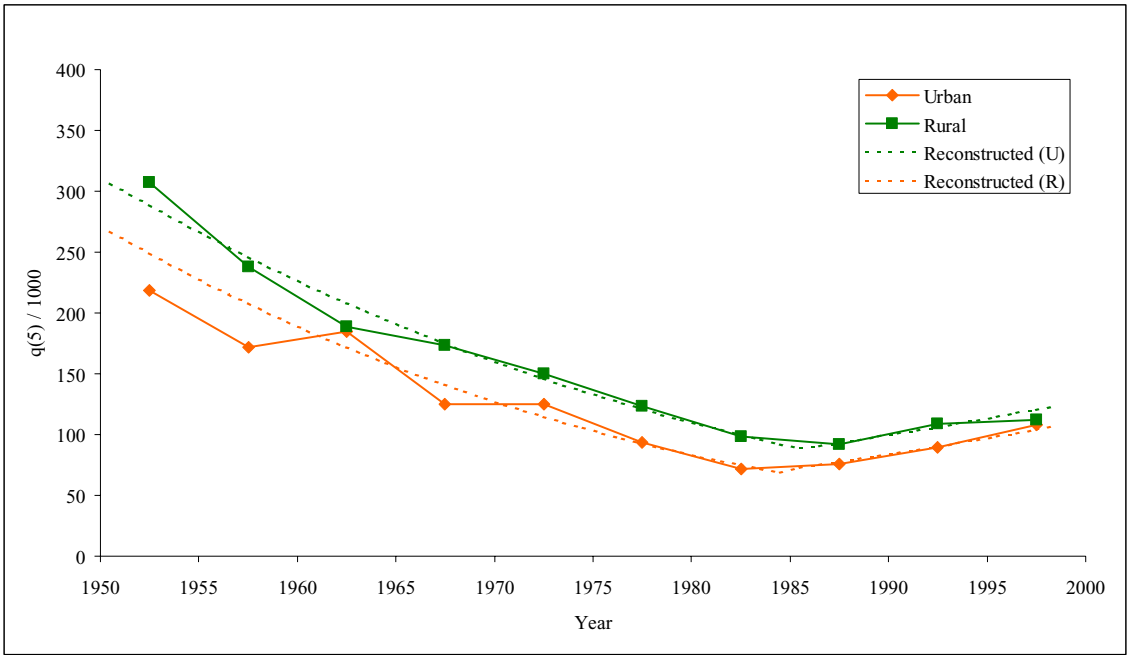


In the case of Kenya (Figure 6), indirect estimates come from censuses conducted in 1948, 1960, 1970, and 1980. Indirect estimates appear to be close to the reconstructed values, and the values before 1950 are consistent with the reconstructed trends. Average values of points located between 1948 and 1978 are virtually identical to reconstructed estimates (210 and 208 per 1,000, respectively). Indirect estimates fall within a +/- 20 percent range of reconstructed trends (+19 percent for the 1970 census and -19 percent for the 1948 census), which indicates the inaccuracy associated with indirect methods. Trends also would be approximately the same between 1948 and 1978. Logistic slopes were -4.3 percent and -3.8 percent respectively. Direct estimates published by DHS surveys are almost identical to the authors' reconstructions, a finding expected since the data are the same. However, the reconstructed series goes back to earlier periods, and the yearly estimates as well as the two-year estimates allow better documentation of the inflexion point. The World Health Organization (WHO) series, based on a mixture of direct and indirect estimates, is less precise. They erased the inflexion point, neglected the mortality increase after 1985, and underestimated the slope between 1955 and 1985 (-2.6 percent compared with -4.3 percent observed). All of these elements are important in documenting the mortality transition in Kenya. The reconstructed series without AIDS indicates that under-five mortality increased in Kenya after 1985 for causes of death other than those associated with HIV, a result that requires explanation. The 1950-1985 trend predicted a low value of 51 per 1,000 in 1998. Observed values show a marked increase in mortality of an estimated 69 per 1,000 compared with the expected course of the health transition, of which 22 per 1,000 was attributed to HIV/AIDS and 47 per 1,000 to other causes. The reconstruction and the evaluation of the net effect of pediatric AIDS seem therefore to be critical to understanding mortality changes in Kenya, and to analyzing their underlying determinants.

Urban and rural estimates

Similar computations were done by urban and rural residence. Presented here are two-year series and reconstructed trends for urban and rural residence. In Kenya, the trends appear to be similar for urban and rural populations, with almost parallel slopes between 1950 and 1984 (-4.7 percent and -4.3 percent, respectively) and a similar mortality increase after 1985. It can be seen that mortality may have increased a few years earlier in urban areas, though precise estimates of inflexion points and ways of testing the differences are lacking or would require other types of modeling.

Figure 7: Reconstructed under-five mortality trends in urban and rural areas, Kenya



RESULTS

Results by country are presented in the appendix, which includes (as much as possible) the same details as those provided for Kenya, plus urban and rural data. Estimated values of under-five mortality by year are provided in the tables in the appendix. These reconstructions were done for 33 countries. Data quality and quantity vary markedly. Reconstruction usually starts in 1950, except in countries for which the data were not available. It should be remembered that data for the period 1950-59 are based on the earliest years of the earliest surveys, and therefore tend to be overestimated because of the bias associated with selecting younger women. They were kept as such, to provide data consistent with later estimates for persons interested in using them for regression analysis over the whole period, in particular for correlations with GDP (gross domestic product) per capita, for which series are available since 1950 for most countries. Estimates of mortality declines in the 1950s will often seem faster than estimates in later periods. This may be partly due to the forecasting method. However, in most countries for which reliable data are available, mortality decline in the 1950s is always dramatic, probably because of the arrival of antibiotics and antimalarial drugs. Estimates stop in the year of the last survey, with ranges from 1987 to 2000. In Lesotho only the WFS survey was conducted in 1977. All the DHS data sets available in early 2003 were included. With the new rounds of DHS surveys, more data is coming that will allow researchers to complete estimates for the entire 1950-2000 period for many countries. The reconstructed trends allow a basic typology of health transitions in sub-Saharan Africa.

Regular mortality decline

Among the 33 countries studied, only nine had a regular health transition; that is, a steady decline in under-five mortality over the period covered by the surveys. They were Benin, Burkina Faso, Comoro Islands, Ethiopia, Guinea, Liberia (up to 1986), Mali, Chad, and Togo. All these countries had high levels of mortality in 1950, and exhibited no reversals in mortality trends throughout the period covered by the surveys. The case of Liberia is unusual because no data were available after 1986. This situation is probably due to the civil war there during the 1990s. The analysis indicates that only a few African countries have had a smooth health transition.

Short-term increases in mortality

Despite a steady decline in mortality, some countries experienced a few years of excess mortality that did not substantially affect overall trends. For instance, in Burkina Faso mortality increased in 1994-95 in rural areas but not in urban areas. In Lesotho mortality increased significantly between 1962 and 1965. In Namibia, mortality increased during the struggle for independence (1977-82), then decreased until the arrival of HIV/AIDS in the 1990s. Similarly, mortality increased in Zimbabwe during the struggle for independence (1978-82) in that country. In Nigeria, mortality increased during the Biafra war (1964-68). In Chad, mortality increased in 1980-81, and in Togo, mortality increased in rural areas in 1993-94. However, all these changes appear to have been transitory because they did not have any substantial long-term effects on mortality trends.

Changing trends in under-five mortality: Political and economic crises

Several countries went through prolonged periods of mortality increase as a result of political crises, economic downturns, or civil war. In Angola, the limited data available

showed that under-five mortality declined during the late colonial period and the years following independence (1975-79), then increased during the civil war years (1980-89). A similar pattern prevailed in Mozambique, a country that went through similar political change and was also strongly affected by civil war. In Ghana, under-five mortality increased between 1979 and 1983, during a severe political crisis. In Madagascar, mortality increased during the Malagasy revolution period (1975-86), when GDP per capita underwent a rapid decline. In Nigeria, mortality increased between 1978 and 1988 in rural areas, and stagnated in urban areas during the same period. In Uganda, mortality increased markedly during the Idi Amin Dada years (1971-79) and the few years of political uncertainty following his departure (1980-84), until a stable situation returned with the arrival of Yoweri Museveni (1986). In Rwanda, as in Burundi, mortality increased in the period after independence (1965-76). In Rwanda, mortality increased during the attacks of the Tutsi refugees after 1991, peaked during the genocide (1994), and rose again in 1998. In Tanzania, mortality increased during the 1979-85 period, particularly in urban areas. In Zambia, mortality increased between 1975 and 1992, especially in urban areas, after the major decline in copper prices on the international market (the main export and the main source of income of the country) and during the political and economic crisis that followed. This major downturn occurred even after discounting for the effect of HIV/AIDS.

Stagnation 1980-1990

Several countries underwent periods of stagnation in under-five mortality in the 1980s and 1990s. For instance, in Benin, mortality stopped declining between 1979 and 1989 in both urban and rural areas despite favorable economic indicators. In the Central African Republic, mortality stagnated between 1977 and 1989, a difficult period following the installation and fall of Jean-Bédel Bokassa. In Gabon, mortality stagnated after 1985, even after discounting for the impact of AIDS. In Niger, mortality stagnated in rural areas between 1972 and 1992. In Sudan, mortality stagnated in 1974–84 and even increased slightly in rural areas.

Epidemiological crises (malaria)

In only one case was evidence found of a specific mortality crisis, probably caused by malaria. In Senegal, under-five mortality increased during the period 1960-70, and this increase was associated with an increase in malaria morbidity that followed the failed attempt to eradicate malaria from 1955 to 1959. Malaria mortality increased again in the 1990s, according to local studies, although there was no discernible effect on mortality (all causes).

Mortality increases caused by HIV/AIDS

Pediatric AIDS has had a strong effect in several countries, provoking or exacerbating mortality increases. This is particularly evident in southern African countries (South Africa, Botswana, Zimbabwe, Malawi, and Zambia), in some eastern African countries (Kenya, Uganda, Tanzania), and in one western African country (Côte d'Ivoire). In Zimbabwe and in Botswana, all of the increase in under-five mortality was attributable to HIV/AIDS, whereas in other countries pediatric AIDS contributed to only part of the increase.

Mortality increases after discounting for HIV/AIDS

In several countries, under-five mortality has increased in recent years not only as a result of HIV/AIDS, but also after discounting for HIV/AIDS, according to our model. For

instance, in South Africa, even after subtracting the effects of pediatric AIDS, under-five mortality stopped declining after 1993. In Cameroon, under-five mortality after discounting for HIV/AIDS was 145 per 1,000 in 1998, although a lower level (101 per 1,000) was expected from previous trends. In Côte d'Ivoire, the recent change in under-five mortality remained favorable after discounting for HIV/AIDS, but the slope is much lower than it was before 1983. In Kenya, under-five mortality increased after 1985, even after discounting for HIV/AIDS.

Differentials in mortality change by urban-rural residence

Overall, mortality change in a country is similar in urban and rural areas. However, several cases of differentials in mortality change by urban-rural residence were documented. In Burundi, rural mortality declined between 1976 and 1986, whereas it increased in urban areas. In the Central African Republic, mortality increased in rural areas between 1976 and 1990, but decreased in urban areas during the same period. In Malawi, urban mortality increased substantially after 1984, but mortality remained unchanged in rural areas. In Mozambique, differences in mortality between urban and rural areas occurred during the civil war, and rural areas were most affected. In Niger, mortality remained unchanged between 1972 and 1992 in rural areas, but continued to decline in urban areas.

DISCUSSION

Available data on under-five mortality in sub-Saharan Africa cover only a limited number of countries and a limited number of years between 1950 and 2000. Further, sampling errors as well as several minor biases affect the data. However, the data were sufficient to reconstruct the main trends in under-five mortality, some of the erratic changes, and major mortality increases caused by HIV/AIDS and other causes (such as political and economic crises). The data show that the health transition has been sustained over the period 1950-2000, with a rate of decline in under-five mortality of about -1.7 percent. This decline, however, has been affected by numerous situational factors, some minor increases in mortality, and some major increases in mortality such as occurred as a result of pediatric AIDS.

Explaining these changes, both positive and negative, calls for a renewed look at mortality determinants. On one hand, major changes have occurred in the field of public health, including the increased number of physicians per capita, increased vaccination coverage, and the extensive use of modern medicines, as well as urbanization and modern education, all of which have contributed to mortality decline. On the other hand, political crises, civil wars, poor state management, and, to a lesser extent, economic crises have contributed to increases in mortality. HIV/AIDS arrived in the mid-1980s to complicate the health situation, and now accounts for a large part of recent increases in mortality. Fluctuations in the prevalence of malaria may also have played a role. Recent mortality increases after discounting for the effects of HIV/AIDS require additional explanation. Increases in poverty, particularly in large cities, may explain increases in mortality in places such as Kenya, Cameroon, and Côte d'Ivoire.

This attempt to reconstruct under-five mortality trends has several advantages over earlier estimates. Compared with indirect estimations, which often are out of date, the direct estimates provide more robust levels and trends and more inflexion points. Compared with WHO estimates, which are based on a mixture of direct and indirect estimates, reconstructed trends often show patterns that have been smoothed. Furthermore, discounting the effects of HIV/AIDS allows for better documentation of what portion of mortality is due to emerging diseases and what portion is due to other causes.

This reconstruction was a prerequisite to a detailed analysis of the determinants of mortality change in sub-Saharan countries, whose complexity is readily apparent when examining the country figures. Health transition in sub-Saharan Africa is complex because of several factors, the most important of which seem to be political instability, poor state management, and emerging diseases. The diversity of situations among the countries should be taken into account to better understand the various patterns of under-five mortality seen during the second half of the twentieth century.

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Appendix

Under-five Mortality Trends in Africa:

Country Estimates

1. Angola

Angola is the only country in this study for which no Demographic and Health Survey (DHS) was conducted. However, given the economic importance of this country and its difficult internal political situation, we reconstructed mortality trends using the limited information available from the Portuguese census of 1940 and the Multiple Indicator Cluster Survey (MICS) conducted in 1996. Compared with a formal DHS survey, the MICS survey has two serious shortcomings: It is based on only the last three births instead of a full maternity history, and it does not cover the areas controlled at that time by UNITA, the rebel movement. However, the results from the recent period are so dramatic that we decided to include them. Brass-type data from the 1940 census were taken from Dr. da Costa Carvalho's dissertation (da Costa Carvalho, 1978), from which indirect estimates were derived using the United Nations General Model for developing countries. Results indicate an average value of q(5) of 363 per 1,000 in 1927 and 392 per 1,000 in 1937, a level roughly equivalent to A. Hill's estimates (Hill, 1991) with the South Model (362 per 1,000 in 1935). It should be noted that mortality rose between 1927 and 1937, although documentation is not available. We considered only the last point as a starting point for the trends. The MICS survey gives a first value of 197 per 1,000 in 1977. We applied a straight linear-logistic trend between these two points, with a slope of -2.7 percent per year, which is realistic. Of course, any anomaly or change in trends over that period would have been smoothed out by this procedure. From 1977 on, the MICS data indicate a rapid decline in mortality between 1977 and 1986 (99 per 1,000), then a rise of equal magnitude between 1986 and 1993 (185 per 1,000), and then another decline (142 per 1,000) in 1996. Both trend changes are highly significant ($P = 6{,}58\ 10^{-9}$ and $9{,}82\ 10^{-8}$, respectively). They are also evident in both urban and rural areas. Our estimates, especially those relating to trends, are quite different from the estimates of the World Health Organization (WHO). Our reconstruction indicates that mortality decreased at a moderate rate in the last 25 years of the colonial period (1950-75), then declined dramatically in the first few years after independence. Mortality rose during the difficult years of the civil war, before stabilizing after the first peace agreement was reached; it then started a moderate decline. This situation is much like that of Mozambique, a country with a similar political evolution.

Figure 1a. Trends in under-five mortality, Angola, total

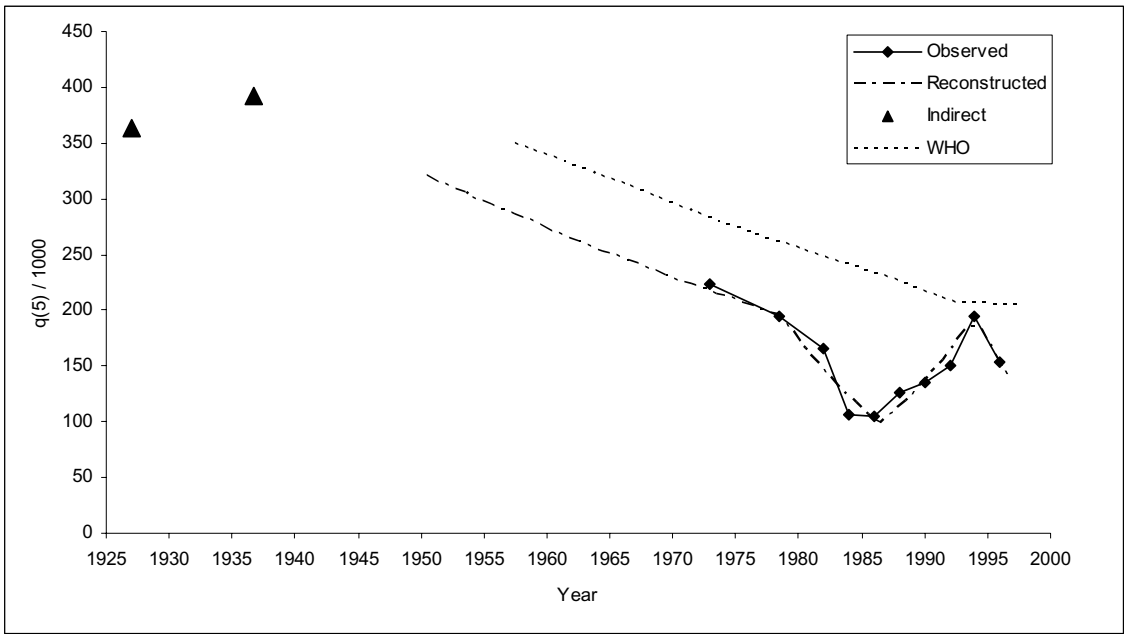
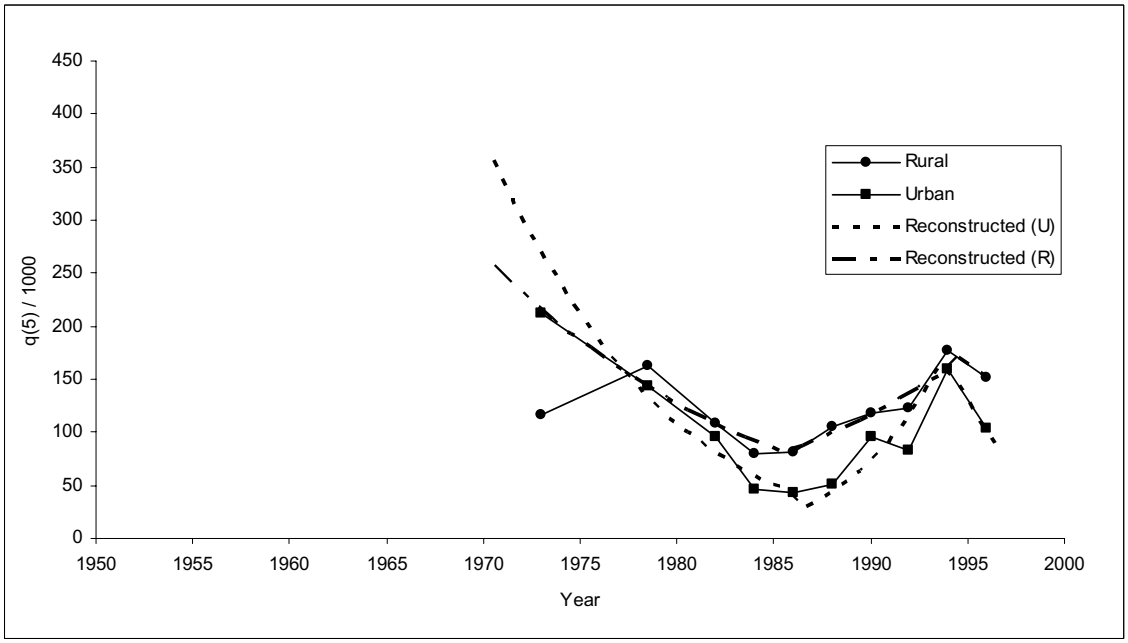


Figure 1b. Trends in under-five mortality, Angola, urban and rural



2. Benin

Benin conducted a World Fertility Survey (WFS) in 1982 and DHS surveys in 1996 and 2001. Together, these surveys provide substantial information on under-five mortality for the period 1950-2000. The three surveys are markedly consistent during the overlapping periods (1970-81 and 1970-95) in levels of mortality. Combined data indicate a change in trends in 1979-89, a period during which mortality remained almost stable. The changes in slopes before 1979 and after 1989 are both highly significant (P = 0.0003 and P = 0.001, respectively). We considered therefore three monotonic periods: 1950-79, during which under-five mortality declined from 426 to 222 per 1,000; 1979-89, when it remained around 211 per 1,000 (the slope is not different from 0); and 1989-2001, when mortality declined from 199 per 1,000 to 139 per 1,000. No point was significantly different from the reconstructed trend. During the period 1950-79, mortality decline was similar in urban areas (330 to 175 per 1,000) and in rural areas (447 to 244 per 1,000), with similar slopes (-2.9 percent and -3.2 percent, respectively). The stagnation of the 1979–89 period was more pronounced in rural areas (slope of -0.7 percent) than in urban areas (slope of -1.3 percent), with none of the difference being significant. The recovery occurred somewhat earlier in rural areas during the 1989-2001 period. Over the whole period, the absolute gap between urban and rural areas was markedly reduced, from an estimated 117 per 1,000 to 37 per 1,000. Indirect estimates are consistent with the reconstruction. The WHO estimates neglect the stagnation period of 1979-89. The impact of AIDS remains small in Benin, and was estimated at 11 per 1,000 in 2000.

Figure 2a. Trends in under-five mortality, Benin, total

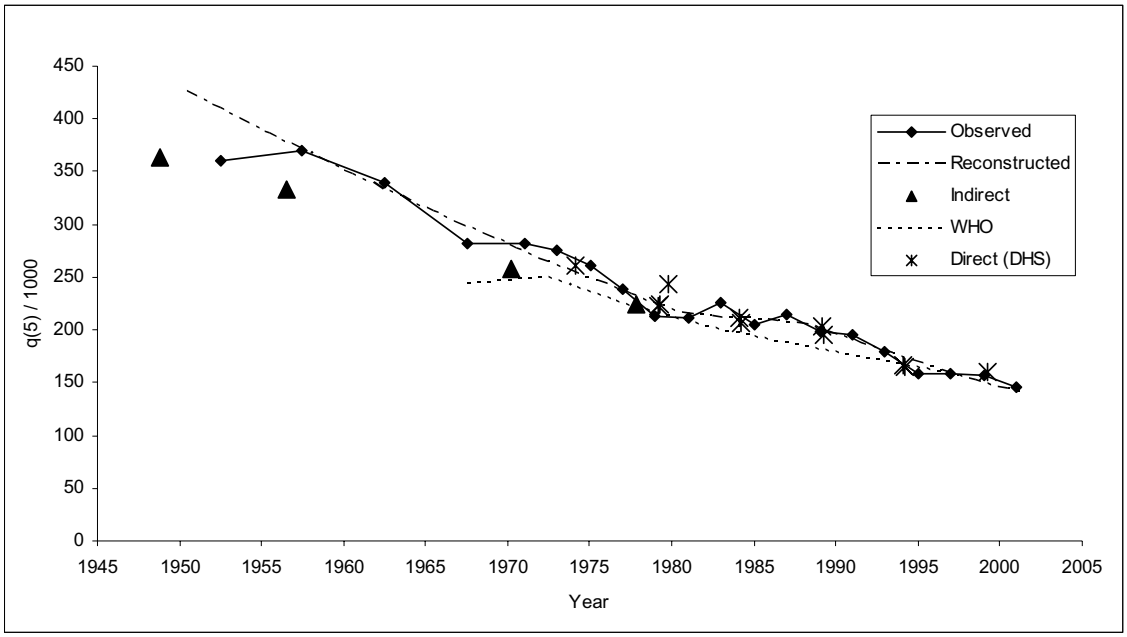
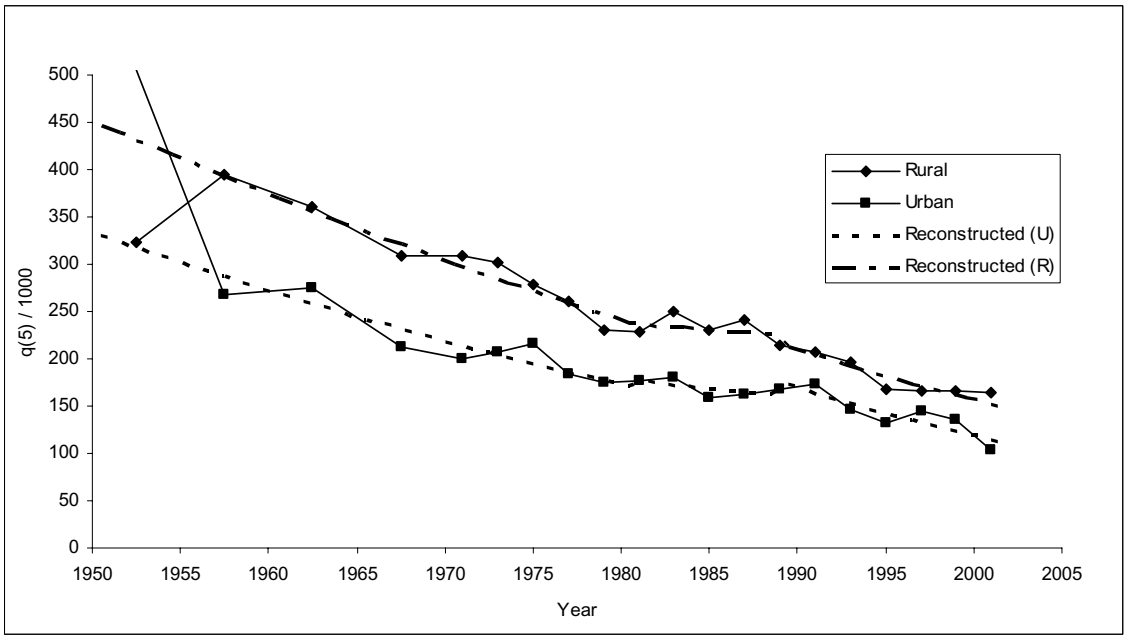


Figure 2b. Trends in under-five mortality, Benin, urban and rural



3. Botswana

The only DHS survey in Botswana was carried out in 1988. The survey shows a steady decline in mortality from 1958 (176 per 1,000) to 1986 (47 per 1,000), one of the lowest levels in Africa at that time. The reconstructed mortality decline is similar to that of the WHO study and close to indirect estimates, but presents a lower level. The last two years indicate a sharp increase in mortality to 67 per 1,000 in 1998; the rise is significant ($P = 0.02$). The AIDS impact model predicts an increase above baseline levels of 51 per 1,000 by 1995 and of 84 per 1,000 in 2000. This increase is consistent with the rise observed between 1986 and 1988. During the 1958-86 period, levels and trends were similar in urban and rural areas (174 to 49 per 1,000 and 171 to 51 per 1,000, respectively); similarly, mortality increased in both areas of residence in the past few years. The lack of difference between urban and rural areas in Botswana is atypical for African countries, and suggests efficient health services and good living conditions in the countryside.

Figure 3a. Trends in under-five mortality, Botswana, total

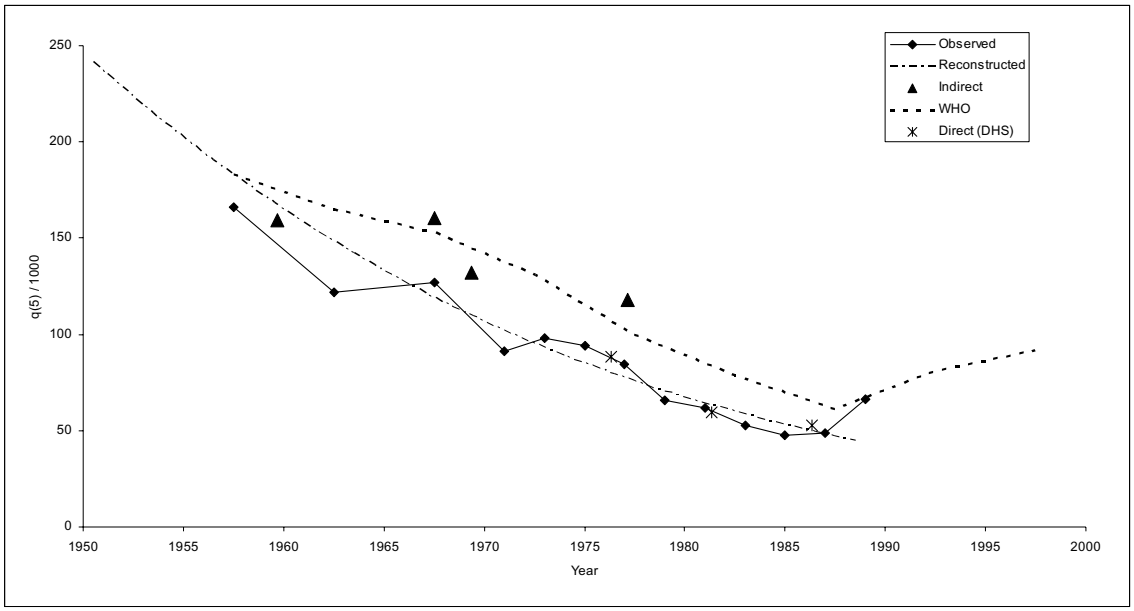
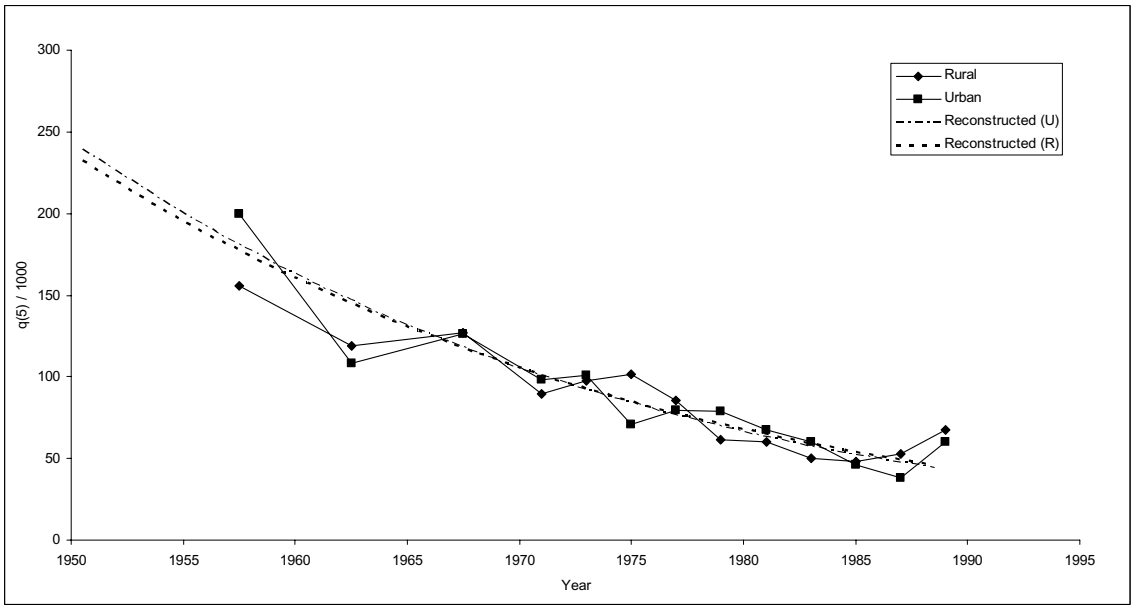


Figure 3b. Trends in under-five mortality, Botswana, urban and rural



4. Burkina Faso

DHS surveys were conducted in Burkina Faso in 1993 and 1999. Mortality data from the two surveys are consistent in terms of trends, although the most recent survey provides somewhat higher estimates—significantly higher for the 1970-79 period, but not significantly different for the 1980-89 period. Overall, Burkina Faso has undergone a steady decline in under-five mortality. According to the reconstructed trend, mortality declined from 382 per 1,000 in 1960 to 168 per 1,000 in 1998. Two anomalies departing from the trend can be seen: In 1973-74, mortality was above the trend ($q(5) = 295$ per 1,000, $P = 8.82\ 10^{-9}$), which corresponds to the drought period in the Sahel and was apparent in both surveys. The second anomaly, seen only in the second survey, occurred in 1993-95 ($q(5) = 189$ per 1,000, $P = 1.37\ 10^{-11}$). Furthermore, some uncertainty remains regarding trends for the 1950-72 period: The 1992 data indicate higher levels, although reconstructed trends parallel the indirect estimates. Reconstructed trends also parallel the WHO estimates, although at a somewhat higher level. Trends in urban and rural areas were parallel during the 1960-98 periods (from 300 to 109 per 1,000 and from 432 to 189 per 1,000 respectively). However, mortality, which stagnated in urban areas between 1989 and 1999, continued to decline in rural areas. Excess mortality in 1973-74 was evident in both urban and rural areas, whereas excess mortality in 1993-95 was apparent only in rural areas. Pediatric AIDS, estimated at 14 per 1,000 in 1995 and 17 per 1,000 in 2000, has played a minor role in under-five mortality.

Figure 4a. Trends in under-five mortality, Burkina Faso, total

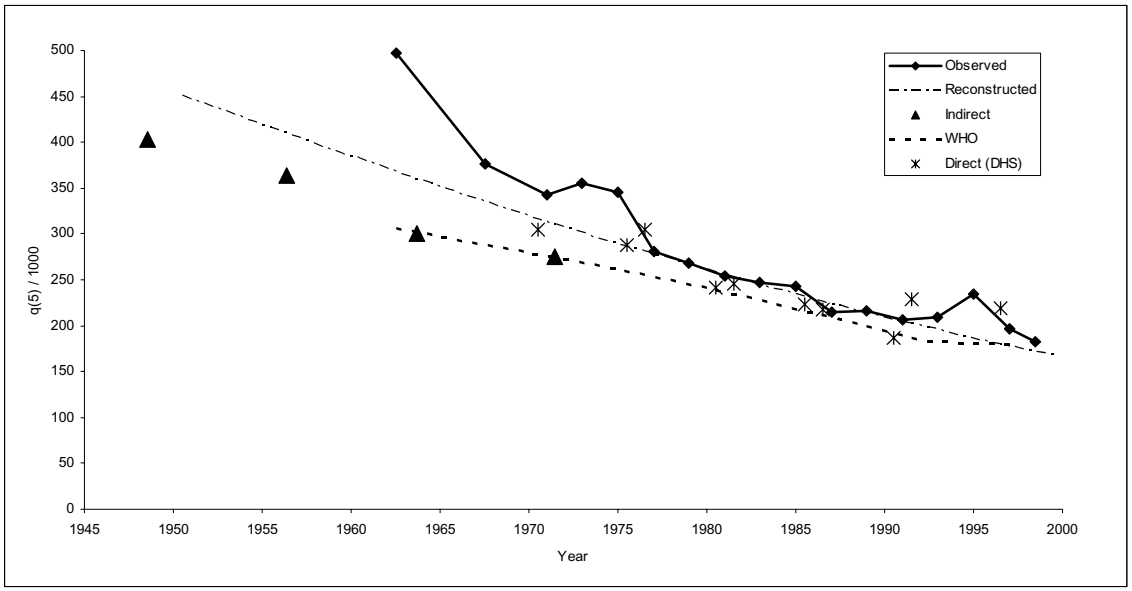
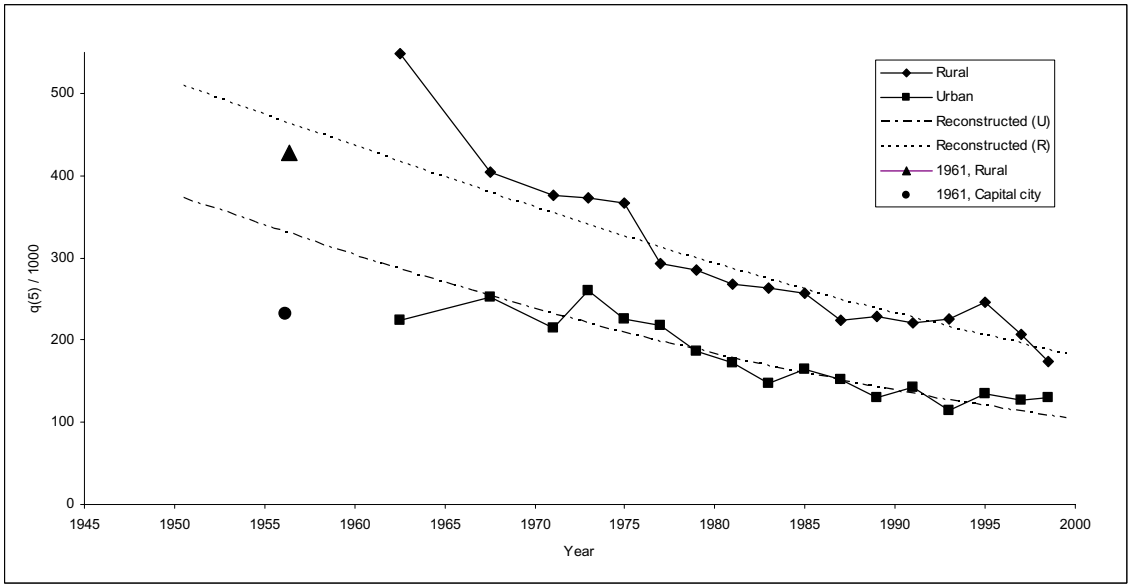


Figure 4b. Trends in under-five mortality, Burkina Faso, urban and rural



5. Burundi

Burundi conducted one DHS survey in 1987. This survey is important because it shows a reversal in under-five mortality trends quite similar to that of neighboring Rwanda, which has a similar history and similar ethnic groups. Under-five mortality declined between 1950 (321 per 1,000) and 1965 (216 per 1,000), then increased through 1975 (233 per 1,000), and then declined in 1987 (130 per 1,000). In Burundi, changes in mortality differ by urban-rural residence. Rural mortality declined between 1977 and 1987 (268 to 142 per 1,000), whereas urban mortality tended to increase during the same period (159 to 171 per 1,000). As a result, urban mortality was higher than rural mortality in 1985-87 (174 and 132 per 1,000, respectively,); however, the difference was not significant, $P = 0.074$. Reconstructed trends were consistent with direct and indirect estimates, although somewhat different from the WHO estimates. Pediatric AIDS did not play a significant role in 1987 (estimated at 8 per 1,000), and did not have a substantial impact at the national level until 2000 (estimated at 13 per 1,000). AIDS did, however, have a large impact in urban areas—estimated at 28 per 1,000 in 1987—and could explain the urban-rural differential in under-five mortality in 1985-87. The impact of AIDS in rural areas was much less (estimated at 7 per 1,000) at the same time.

Figure 5a. Trends in under-five mortality, Burundi, total

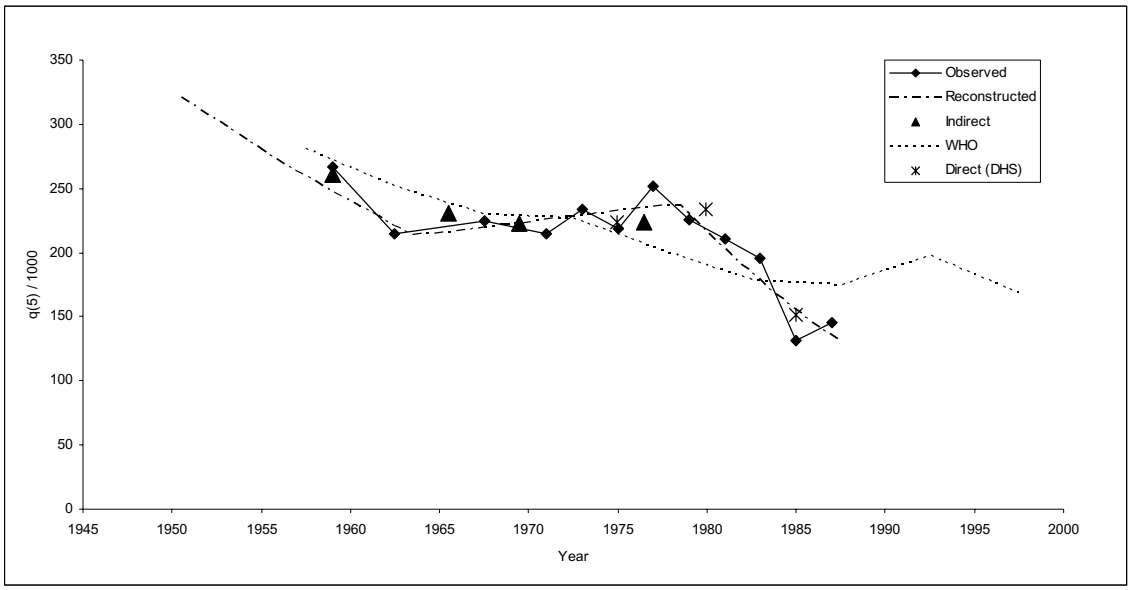
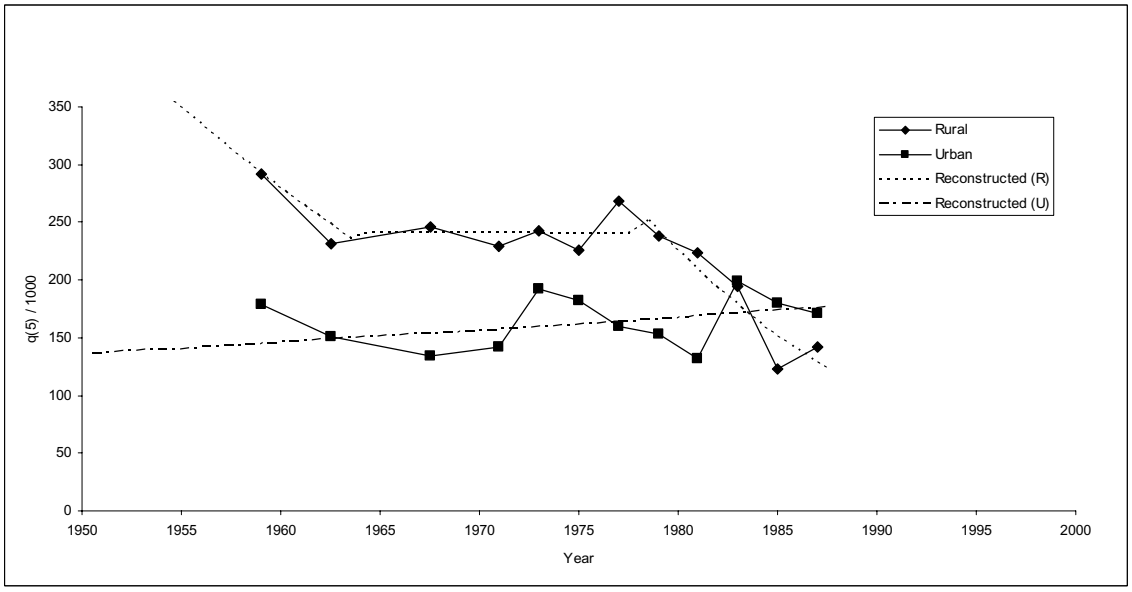


Figure 5b. Trends in under-five mortality, Burundi, urban and rural



6. Cameroon

Cameroon conducted a WFS survey in 1978 and DHS surveys in 1991 and 1998. This permits a mortality reconstruction for the entire period 1950-98. The three surveys are consistent, and provide approximately the same levels and trends during the overlapping periods. Under-five mortality declined steadily from 1950 (336 per 1,000) to 1988 (133 per 1,000), then increased somewhat to 157 per 1,000 in 1998. The reconstructed trend was consistent with other direct and estimates, and with WHO estimates, although the mortality increase from 1988 to 1998 was more pronounced. The changing trend noted in 1988 was evident in urban and rural areas, although it was more pronounced in urban areas. The net increase from 1988 to 1998 could be attributed to pediatric AIDS, which is estimated to have increased from 1 to 14 per 1,000 over the period, with similar effects in both urban and rural areas. This implies, however, that there were other reasons why the mortality decline stopped during this period, which calls for additional explanation.

Figure 6a. Trends in under-five mortality, Cameroon, total

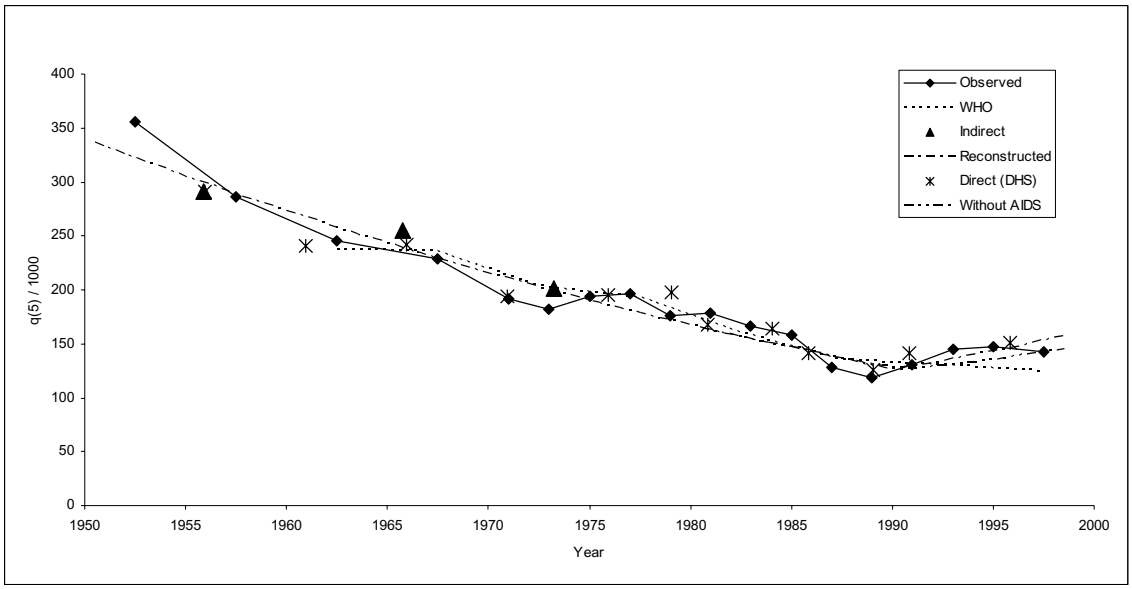
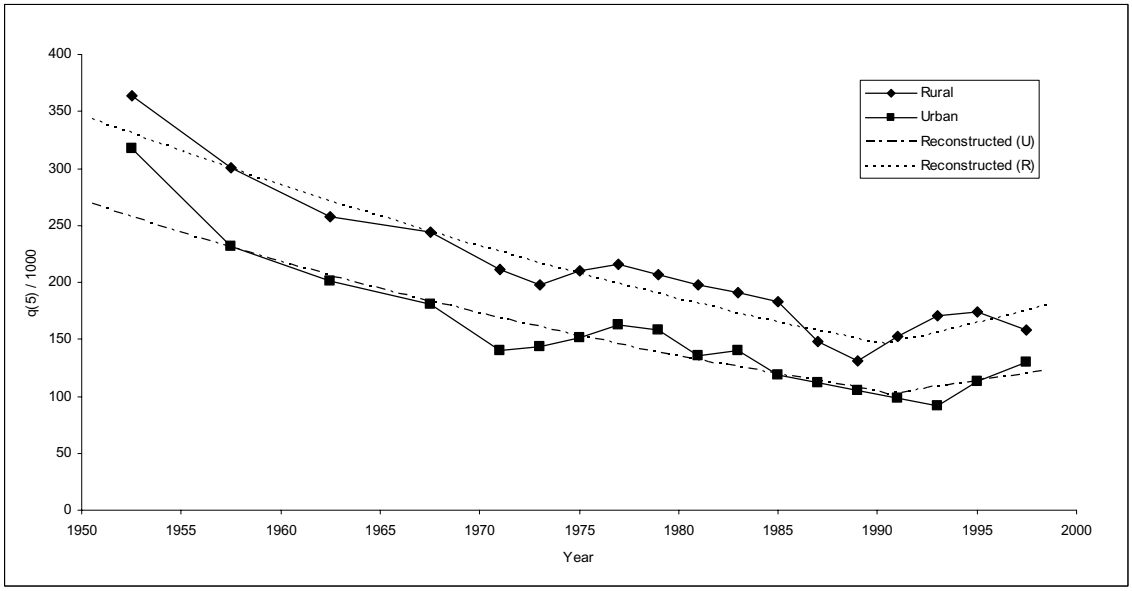


Figure 6b: Trends in under-five mortality, Cameroon, urban and rural



7. Central African Republic

The Central African Republic (CAR) conducted a DHS survey in 1994. Under-five mortality declined between 1950 and 1975, stagnated between 1976 and 1990, then declined again in 1991-94, the most recent data available from this survey. Baseline values from the 1950s are consistent with the indirect estimates drawn from the 1959-60 Demographic Survey. Reconstructed trends are, however, lower than indirect estimates derived from the 1975 census. These later figures appear to be overestimates, and probably affected the WHO reconstruction. The stagnation period corresponds to the controversial political period of Bokassa and the troubled years that followed. The recent decline was highly significant ($P = 0.0005$). Differentials by residence can be seen in changes in under-five mortality. The increase between 1976 and 1990 and the recent decline applied only to rural areas; urban areas continued to experience a slow steady decline in mortality. Pediatric AIDS has played a role in CAR since 1985 and accounted for about 15 percent of under-five deaths in 1994.

Figure 7a. Trends in under-five mortality, Central African Republic, total

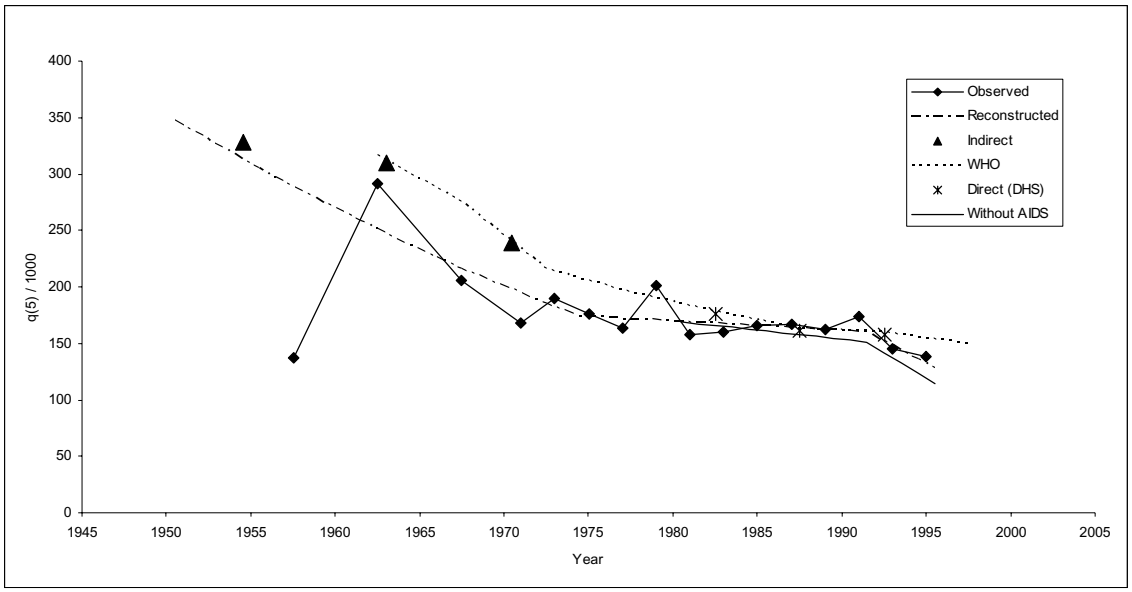
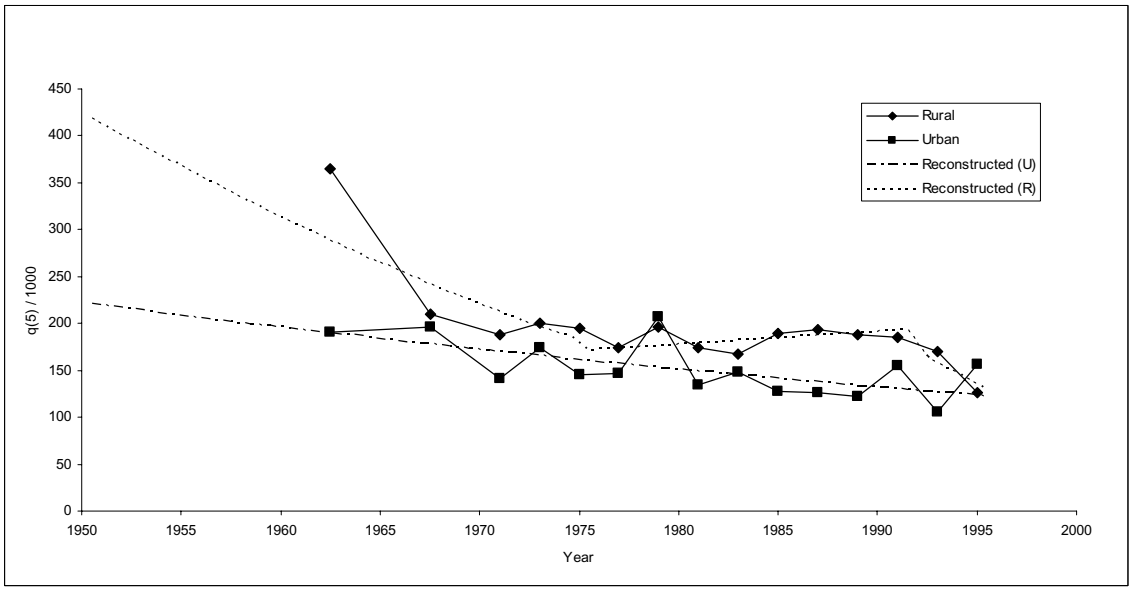


Figure 7b. Trends in under-five mortality, Central African Republic, urban and rural



8. Chad

Chad conducted a DHS survey in 1997. This survey showed a steady decline in under-five mortality from 333 per 1,000 in 1962 to 179 per 1,000 in 1997. The decline was approximately the same in urban (290 to 179 per 1,000) and rural areas (341 to 180 per 1,000). There has been almost no difference in mortality by residence since 1993, which contrasts sharply with neighboring Niger. One anomaly could be noted: excess mortality in rural areas in 1980-81 that is statistically significant (P = 0.044). Annual data indicate that mortality increased from 213 to 319 per 1,000 between 1978 and 1980. This anomaly remains to be explained. Other differences in trends are not significant. Indirect estimates drawn from the 1964 Demographic Survey are consistent with the reconstruction. They show a similar slope, although the estimate is somewhat low (-13 percent). Backward reconstruction, i.e., prolonging the 1962-97 trend back in time, furnishes an estimate of 398 per 1,000 in 1950. This estimate is rough and should be considered with caution. The impact of pediatric AIDS is small in Chad, and was estimated at 7 per 1,000 in 1997.

Figure 8a. Trends in under-five mortality, Chad, total

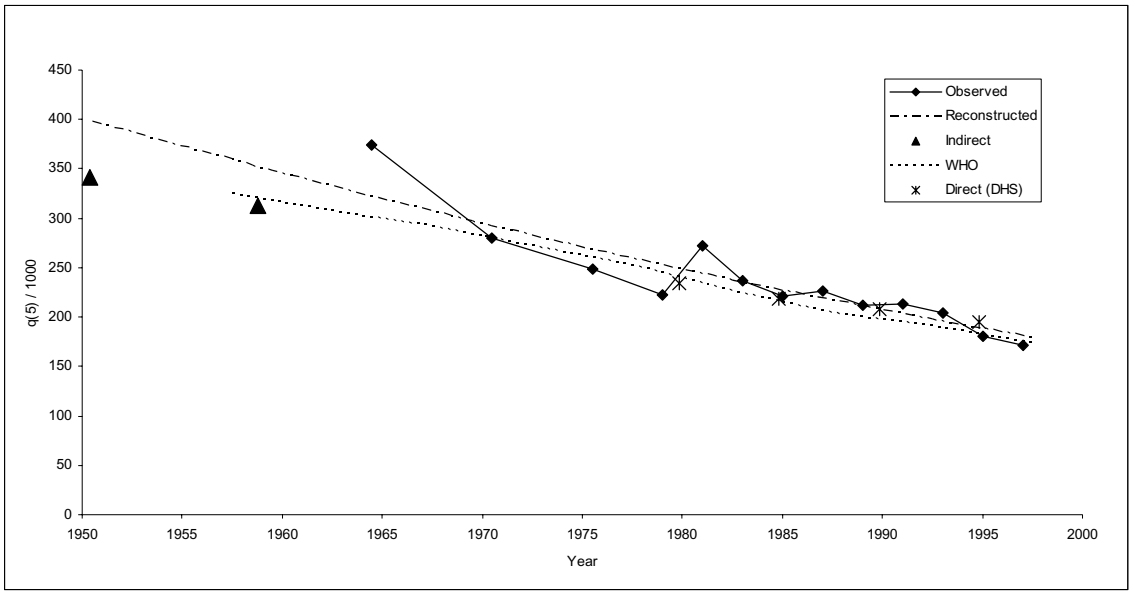
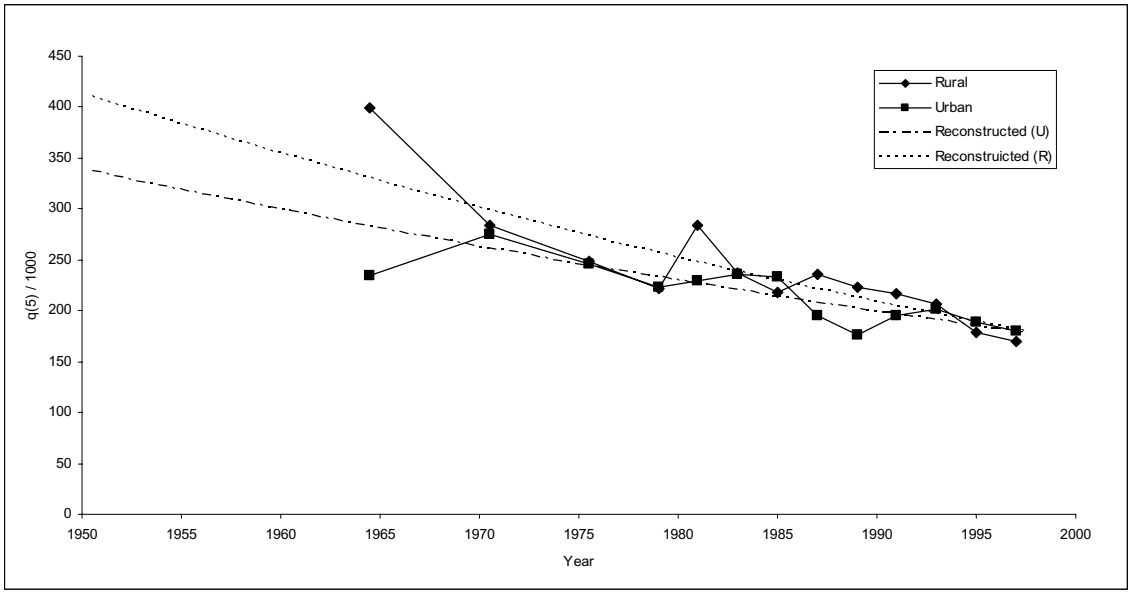


Figure 8b. Trends in under-five mortality, Chad, urban and rural



9. Comoros

Comoros conducted a DHS survey in 1996 using a sample of 3,050 women. Despite the small sample size, the survey allows reconstruction of mortality trends, although at a lower level of accuracy than in other countries. At the national level, under-five mortality has declined steadily since the early 1970s. It is possible, however, that mortality increased in rural areas between 1962 and 1972, although the number of deaths is too small to be conclusive and none of the difference is significant. No other data were found that could confirm the increase noted in rural areas. Trends were similar in urban and rural areas, with convergence in the 1980s and 1990s. AIDS was virtually nonexistent in Comoros during this period.

Figure 9a. Trends in under-five mortality, Comoros, total

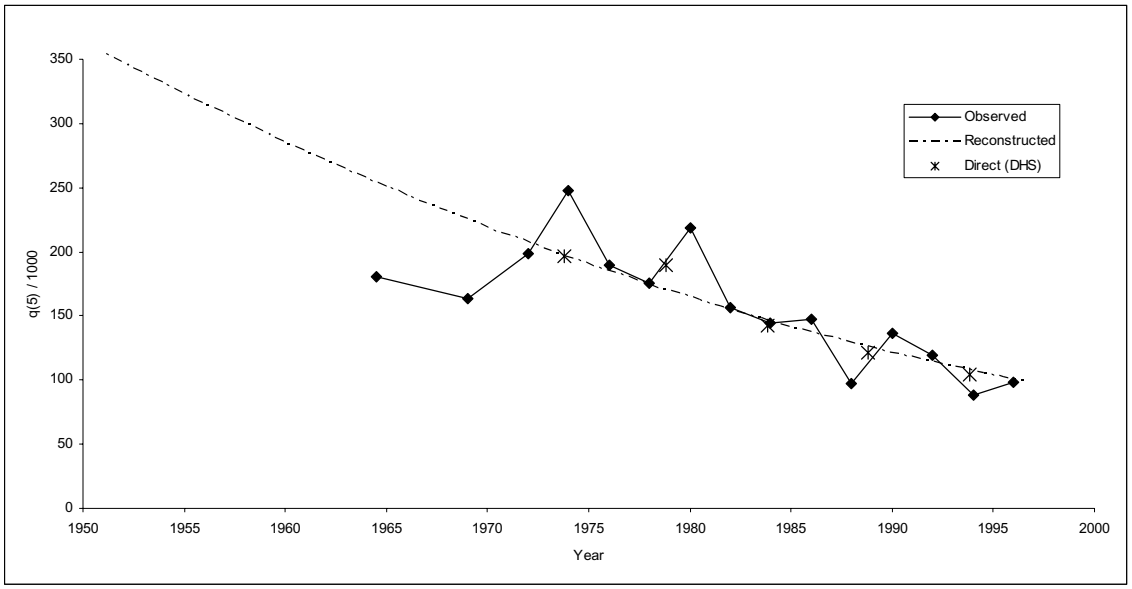
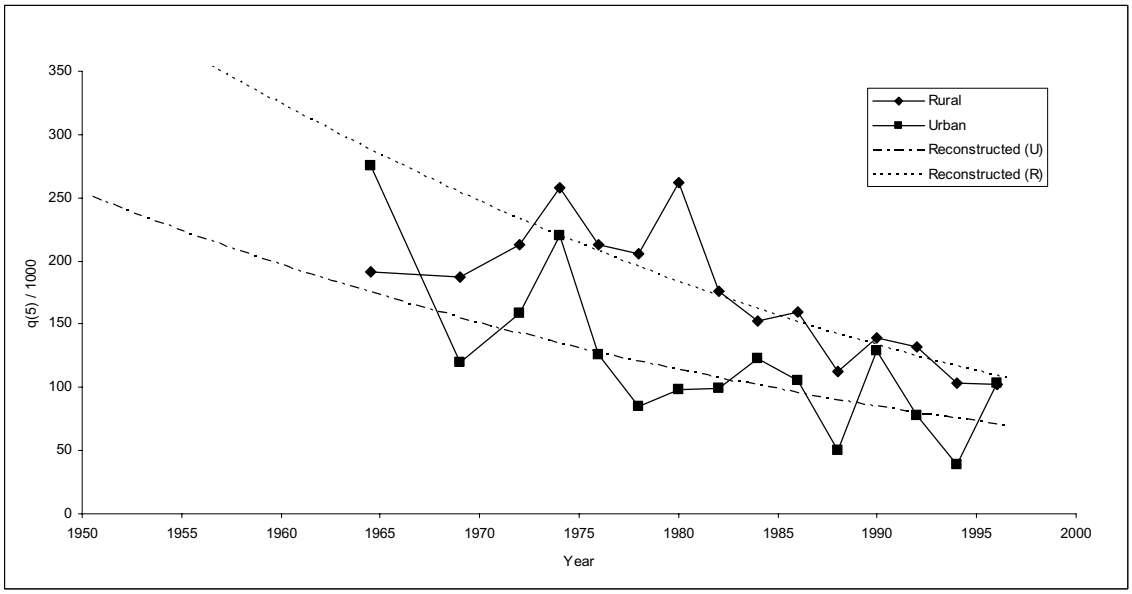


Figure 9b. Trends in under-five mortality, Comoros, urban and rural



10. Côte d'Ivoire

Côte d'Ivoire conducted a WFS survey in 1980 and DHS surveys in 1994 and 1999. This wealth of data allows a full reconstruction of under-five mortality since 1950. The three surveys are markedly compatible for the overlapping periods, and indirect estimates are compatible. They show a steady decline in mortality from 466 per 1,000 in 1950 to 146 per 1,000 in 1983. Then, mortality increased slightly to 158 per 1,000 in 1999. This rise in under-five mortality is attributed to HIV/AIDS, which accounted for 28 deaths per 1,000 in 1999. Without HIV/AIDS, mortality trends since 1984 would have been lower than in the earlier period, and the slope almost nil. In Côte d'Ivoire, HIV/AIDS added to other difficulties, particularly the economic recession of the early 1990s and the difficult political period following President Houphouët Boigny's succession. Mortality changes by residence were roughly parallel in urban and rural areas, with levels in rural areas being about 50 per 1,000 higher than levels in urban areas.

Figure 10a. Trends in under-five mortality, Côte d'Ivoire, total

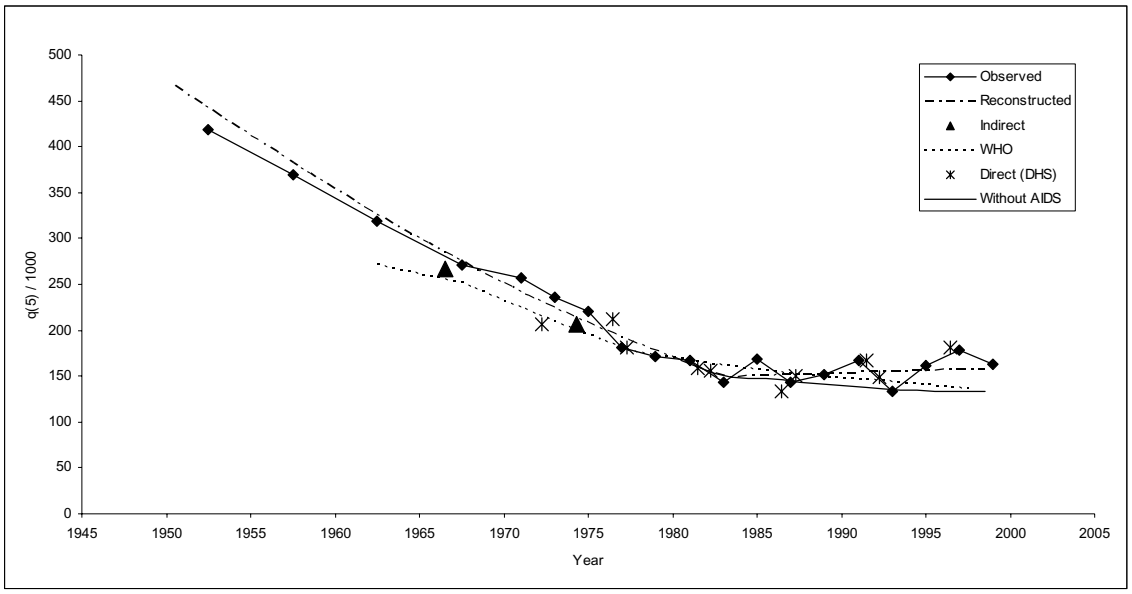
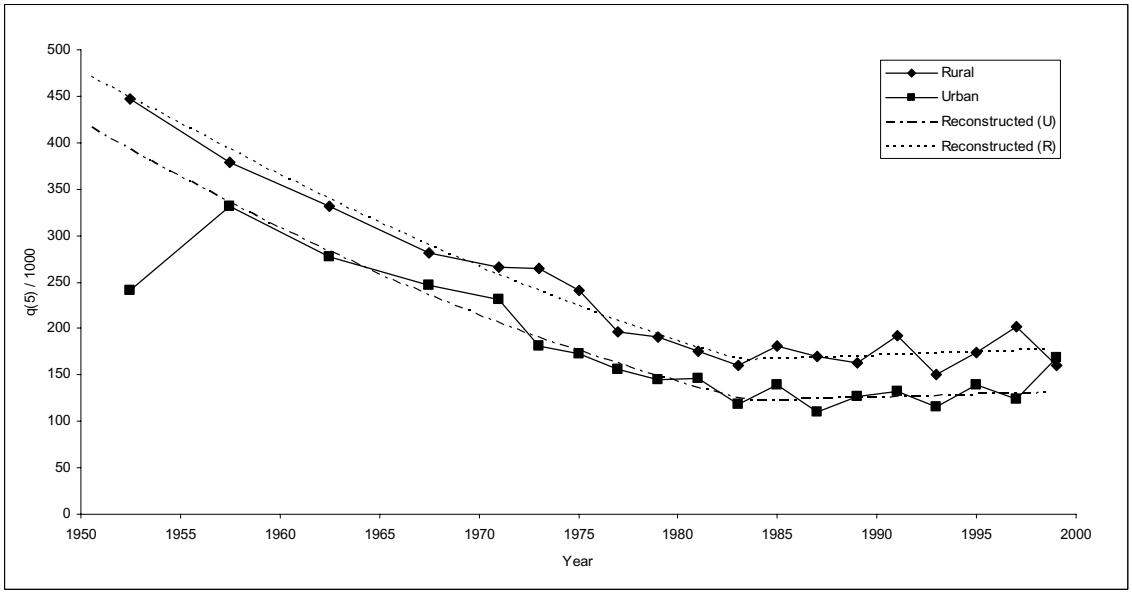


Figure 10b. Trends in under-five mortality, Côte d'Ivoire, urban and rural



11. Ethiopia

Ethiopia was closed to Western influence for a long time, but a DHS survey was conducted in 2000. This survey was based on a sample of 15,367 women, thereby allowing detailed analysis of the data, although for a limited period of time. Extrapolations to the 1950s and 1960s are dangerous. Mortality declined slowly during the period 1967-93, a troubled time marked by the end of the Negus Empire, the installation of a Marxist government, and civil and international wars. From 1993 to 1998, mortality declined rapidly, with the change in the slope being highly significant ($P = 10^{-8}$). The last two years for which data are available indicate a change in the slope, with mortality levels above the expected trend ($P = 0.021$). HIV/AIDS plays a substantial role in mortality in Ethiopia, accounting for 22 percent of under-five mortality in 2000. Without HIV/AIDS, mortality decline would have been smoother and faster after 1993. The trends were similar in urban and rural areas, with a somewhat faster decline in urban areas. Declines in rural areas were slower in the earlier period, but increased in recent years. The low mortality level in 1997-98 is attributable primarily to low mortality in rural areas. The period of rapid mortality decline coincides with the end of the Marxist government, and the opening of the country to the Western world.
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Figure 11a. Trends in under-five mortality, Ethiopia, total

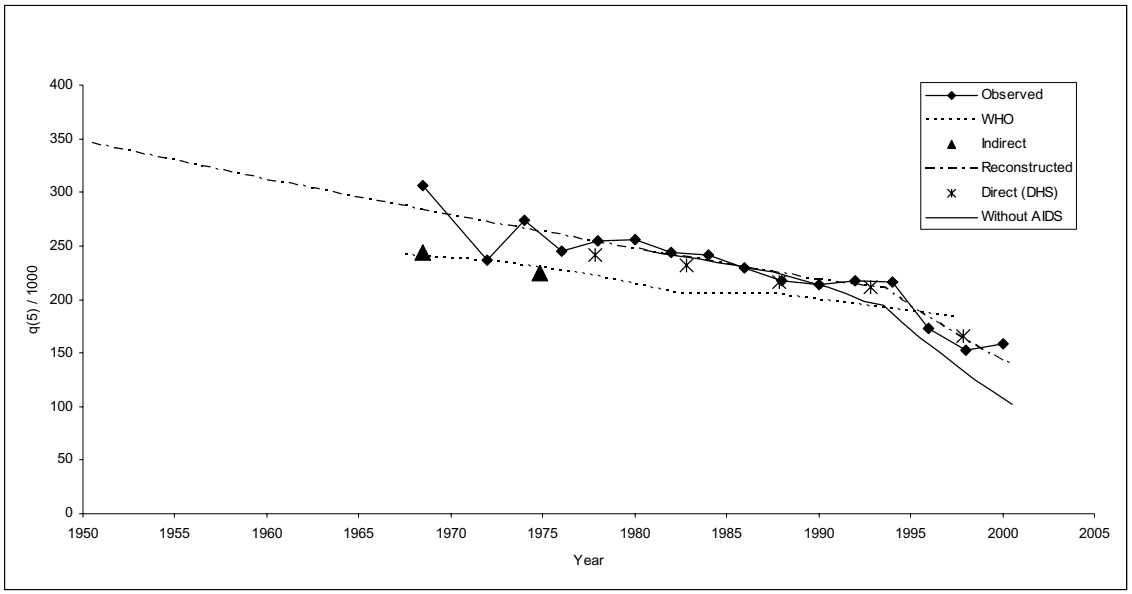
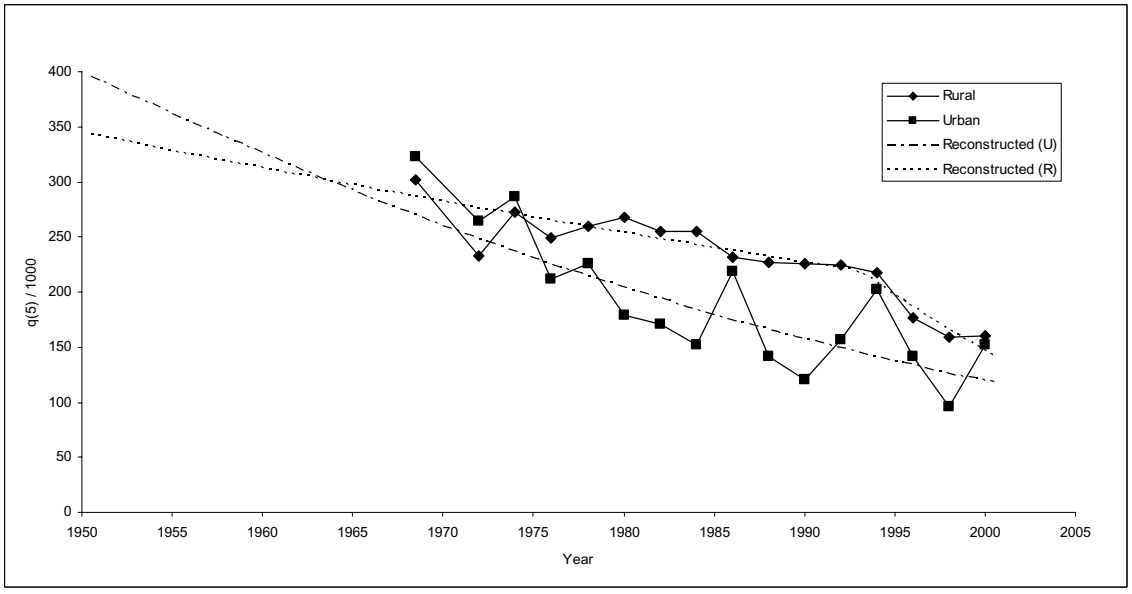


Figure 11b. Trends in under-five mortality, Ethiopia, urban and rural



12. Gabon

Gabon conducted a DHS survey in 2001. The reconstructed mortality data indicate a steady decline in under-five mortality from 1968 (199 per 1,000) to 1984 (100 per 1,000), at an average rate of -5.0 percent. After 1984, mortality remained stable with a slightly declining slope (not significant from 0), reaching 87 per 1,000 in 2000. Under-five mortality trends were similar in urban and rural areas, before and after 1984, although declines were somewhat faster in rural areas in the first period. By 1984, both urban and rural areas had the same level of mortality, which is unusual. Urban and rural mortality remained at a constant level after 1984. Mortality trends between 1968 and 1984 were consistent with earlier estimates of the 1940s and 1950s. We estimated mortality in 1950 to be around 380 per 1,000. WHO estimates are above the reconstructed trends, and miss the reversal in mortality after 1984. HIV/AIDS, estimated at 14 per 1,000 in 2000, has had a moderate impact on mortality in Gabon. Without AIDS, under-five mortality would have continued to decline in Gabon after 1984, although at a slower rate. Causes of this halt in the health transition in Gabon remain to be explored.

Figure 12a. Trends in under-five mortality, Gabon, total

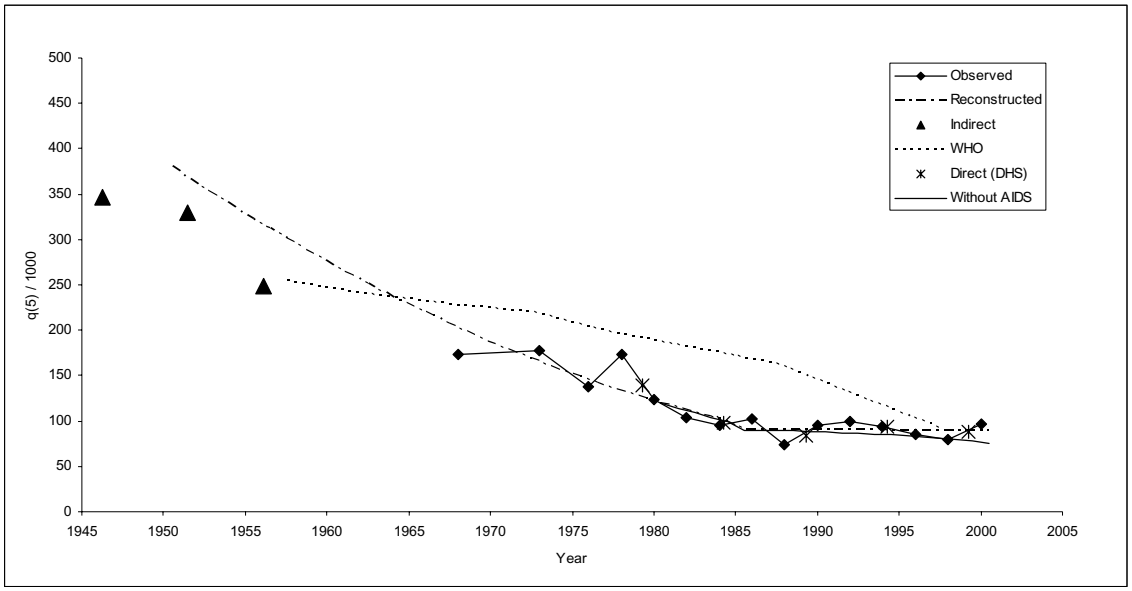
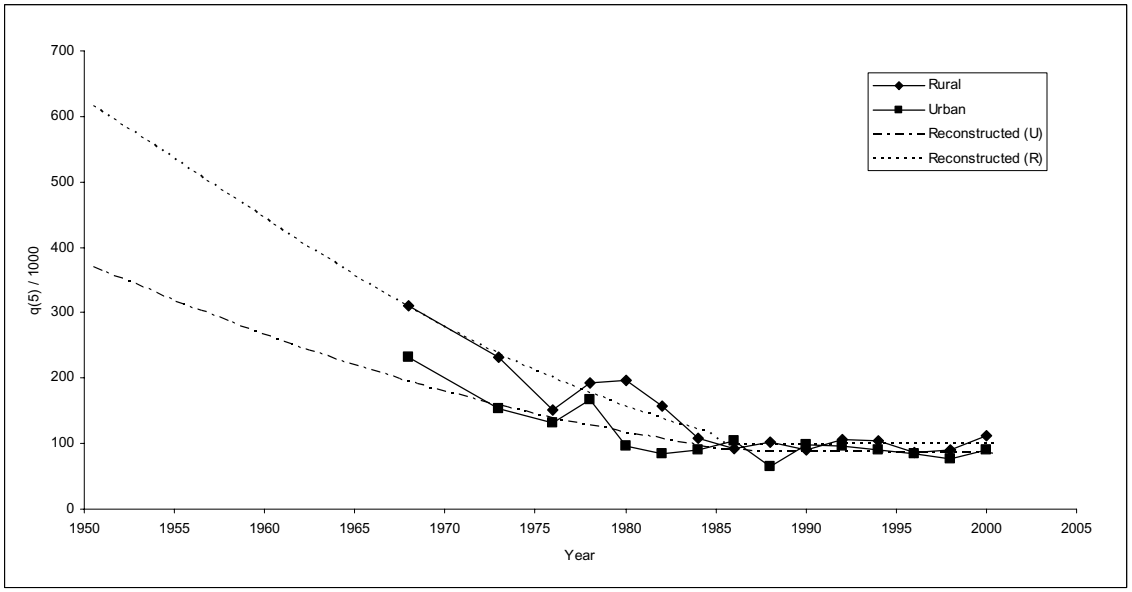


Figure 12b. Trends in under-five mortality, Gabon, urban and rural



13. Ghana

Ghana has a wealth of high-quality demographic data, including a WFS survey (1980) and three DHS surveys (1988, 1993, and 1999). It is also one of the few countries in Africa to have reliable data from before 1950: indirect estimates derived from census data conducted in 1948. Under-five mortality has been declining in Ghana since 1950 (even since 1933, the earliest date for which data are available). Our estimates are consistent with many of the indirect estimates, which are themselves sometimes inconsistent. The decline in under-five mortality has not been regular in Ghana. Decline was rapid between 1950 and 1960 (slope = –6.5 percent), slowed between 1960 and 1978 (slope = –1.5 percent), reversed for a few years between 1979 and 1983 (slope = +3.8 percent), and then resumed a steady decline between 1983 and 1999 (slope = –3.7 percent). All the changes in the slope are highly significant (P = 0,0074; $P < 10^{-5}$; $P < 10^{-8}$, respectively). Mortality changes in urban and rural areas are similar, with similar changes in slopes. Excess mortality in urban areas occurred in 1955–56 (P = 0.002). Differences between urban and rural areas were negligible before 1960, then increased to an average absolute gap of 43 per 1,000 after 1970. HIV prevalence remains low in Ghana, with no noticeable effects on under-five mortality.

Figure 13a. Trends in under-five mortality, Ghana, total

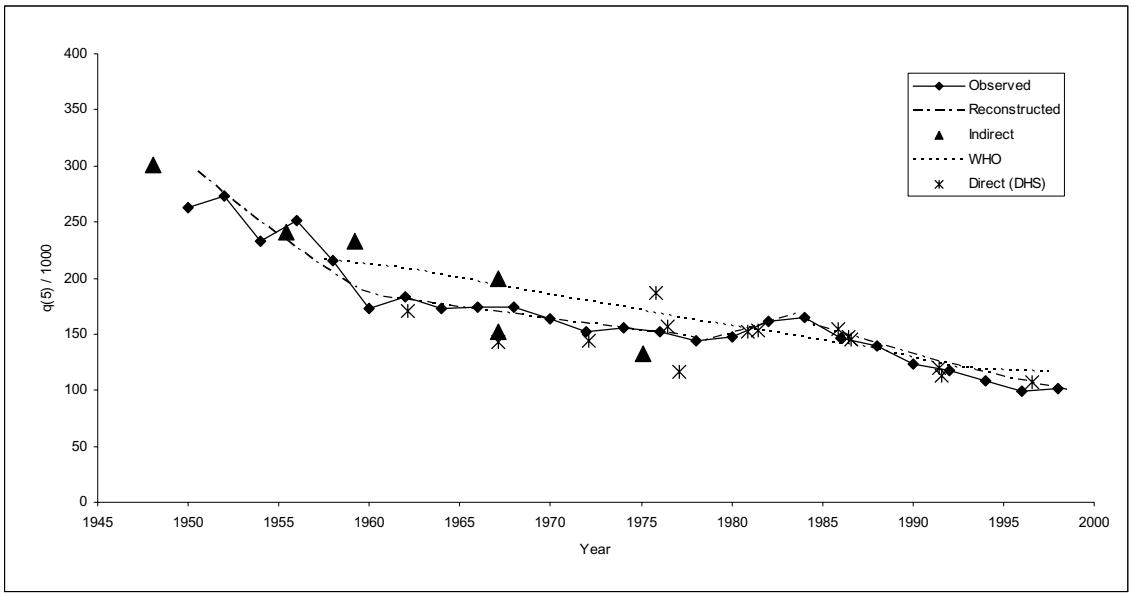
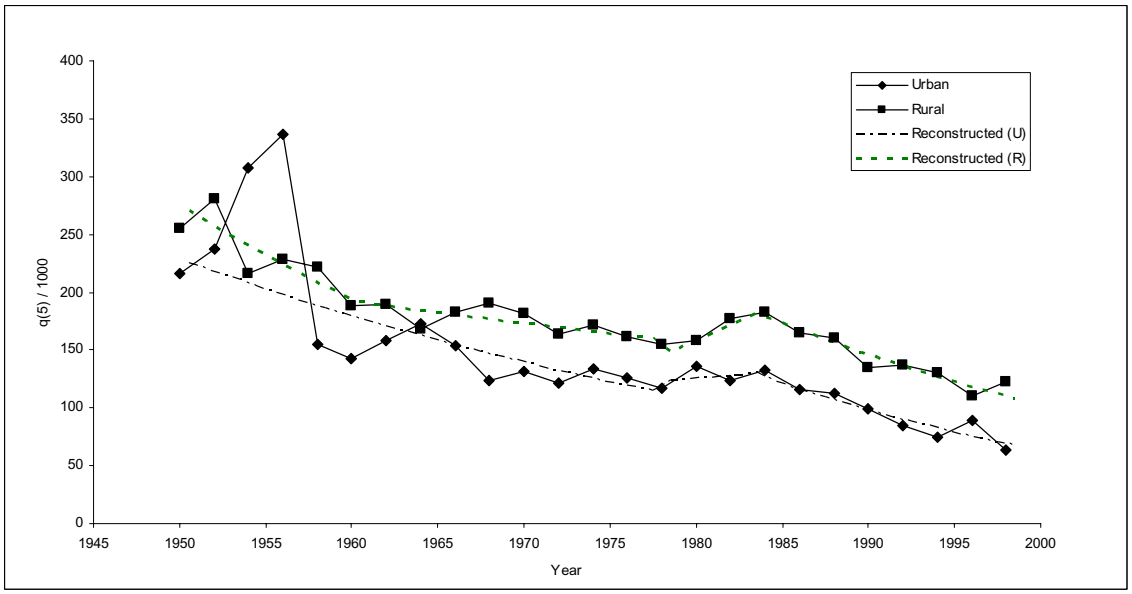


Figure 13b. Trends in under-five mortality, Ghana, urban and rural



14. Guinea (Conakry)

After a sudden break from colonial powers in 1958, and the installation of a dictatorial and bloody regime, Guinea remained isolated from the Western world until the death of the regime leader in 1984. The country conducted DHS surveys in 1992 and 1999, although these were preceded by a demographic survey in 1954-55, the first ever conducted in francophone West Africa. The data indicate a slow decline in under-five mortality between 1950 and 1977, followed by a more rapid decline until 1999. The reconstructed time series is markedly compatible with the 1954-55 survey. HIV prevalence remained low in Guinea until 1999, and had no noticeable effect on under-five mortality. Trends in urban and rural areas were similar during the 1972-99 period, with an average gap of 82 per 1,000. The slow decline in mortality may be explained by the toughness of the political system imposed by President Sekou Touré or by Guinea's political isolation.

Figure 14a. Trends in under-five mortality, Guinea, total

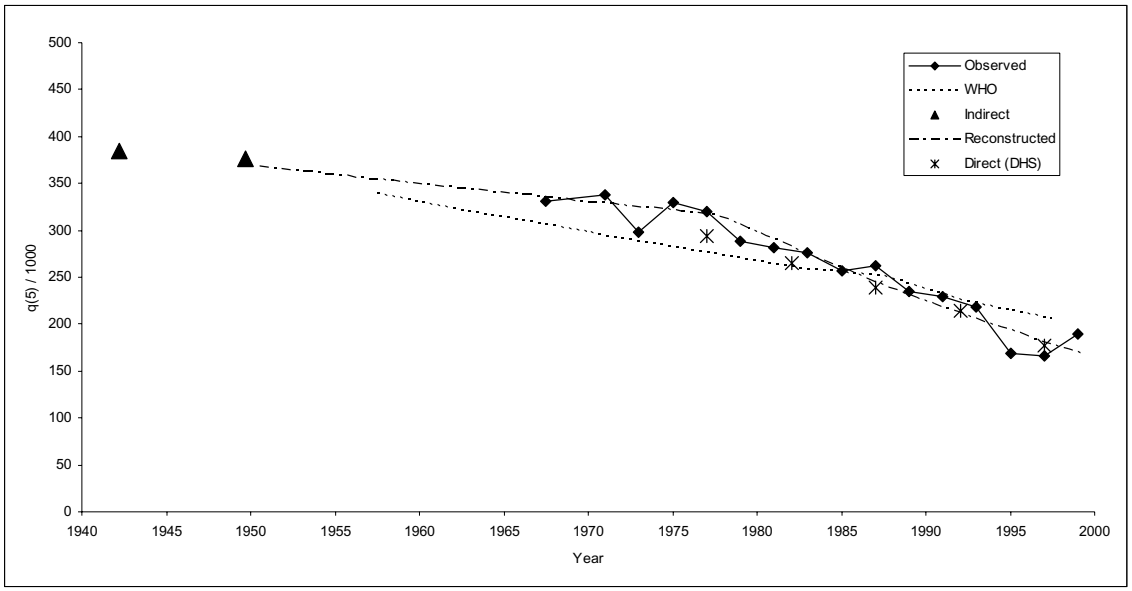
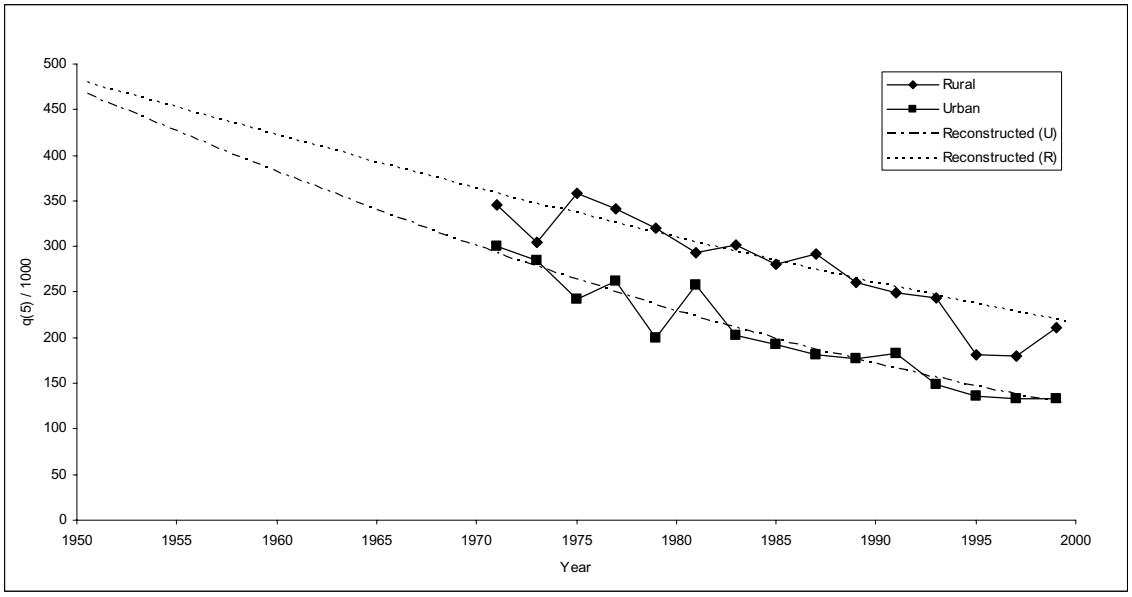


Figure 14b. Trends in under-five mortality, Guinea, urban and rural



15. Kenya

As was the case for Ghana, Kenya also has a wealth of high-quality demographic data: a WFS (1978) and three DHS surveys (1988, 1993, and 1999). It also has indirect estimates of mortality before 1950 derived from census data. Data show a steady decline in under-five mortality until 1985. Under-five mortality was estimated at 296 per 1,000 in 1950 and 87 per 1,000 in 1985, a fast slope of –4.3 percent. The reconstructed trends are consistent with indirect estimates before 1950, but are less consistent with the WHO estimates. Since 1985, however, mortality has been increasing, and reached an estimated 123 per 1,000 in 1999. The rise in mortality can only partly be attributed to HIV/AIDS, which accounted for about 24 deaths per 1,000 in 1999. Even without AIDS, under-five mortality was on the rise. A possible explanation is the increasing poverty in urban areas such as the Nairobi slums, where mortality has increased to a level exceeding that of rural areas. Until 1985, mortality trends in urban and rural areas were similar, with an average gap of 33 per 1,000. After 1985, mortality increased faster in urban areas than in rural areas, thus reducing the gap between urban and rural mortality trends. This change is partly due to HIV/AIDS, which has had twice the impact in urban areas as in rural areas. However, even after discounting for the impact of HIV/AIDS, under-five mortality has increased in both urban and rural areas, a finding that indicates the presence of other problems.

Figure 15a. Trends in under-five mortality, Kenya, total

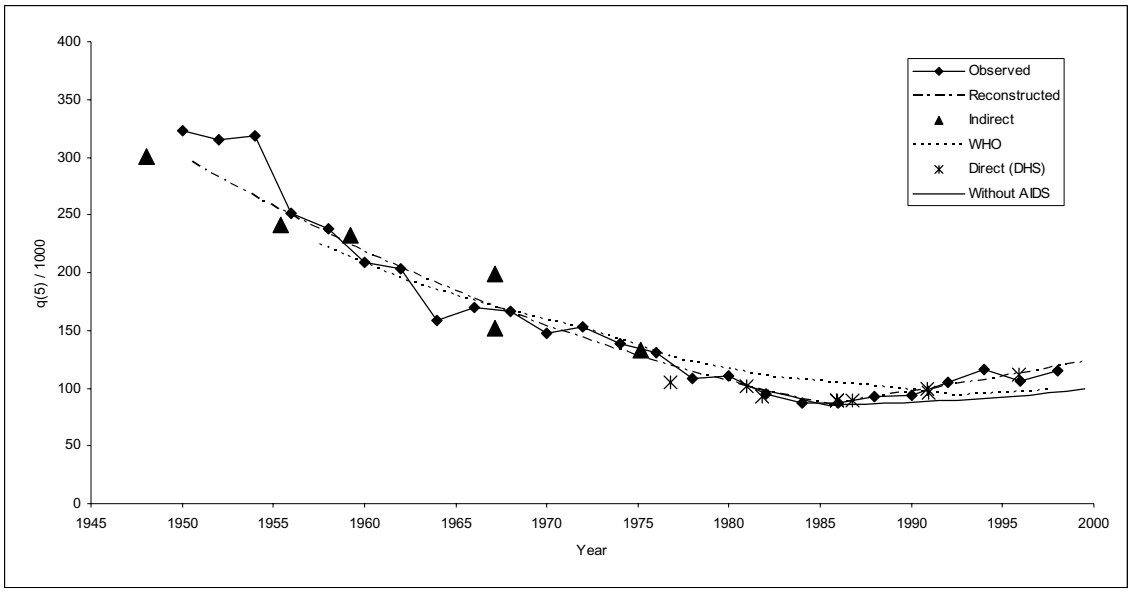
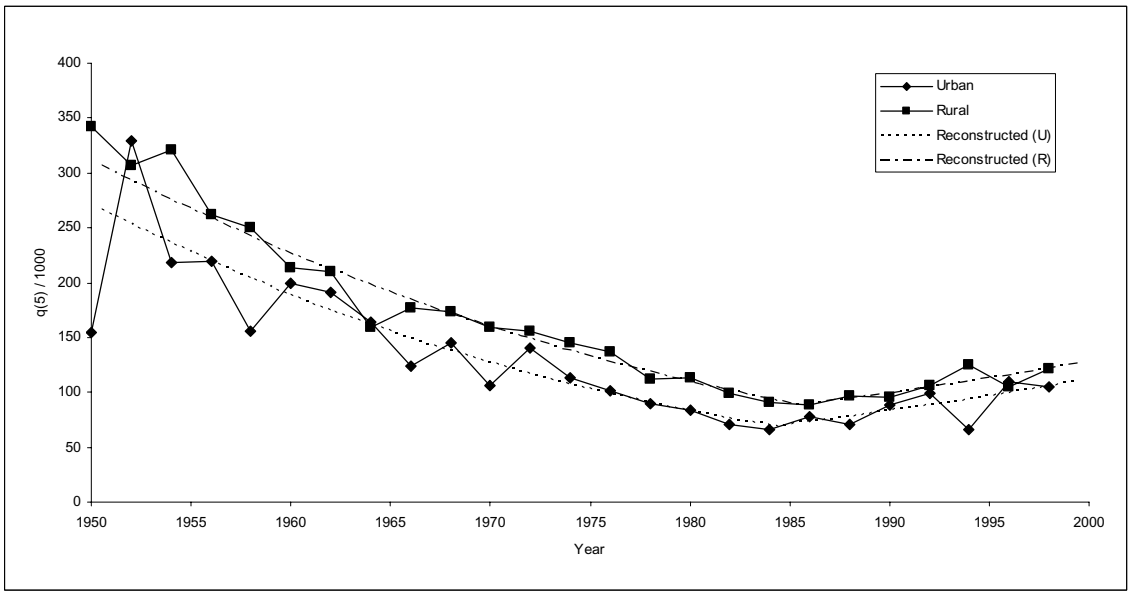


Figure 15b. Trends in under-five mortality, Kenya, urban and rural



16. Lesotho

Lesotho conducted a WFS survey in 1977. This survey is mentioned here only in passing because it covers only half of the 1950-2000 period. Data from this survey indicated a relatively high level of under-five mortality for this part of southern Africa, and a mortality anomaly in the 1960s. Under-five mortality decline was moderate between 1950 (292 per 1,000) and 1961 (176 per 1,000), then increased briefly, reaching a peak of 217 per 1,000 in 1964. Thereafter, mortality decreased steadily to 173 per 1,000 in 1977. These trends pertain primarily to the rural areas because urbanization at that time was very limited and the number of deaths in urban areas was small (five per year on average). As in South Africa, it is likely that pediatric AIDS had a major impact in Lesotho after 1990. AIDS deaths were at 55 per 1,000 in 2000. However, we lack appropriate data to evaluate the impact of AIDS on under-five mortality in recent years.

Figure 16a. Trends in under-five mortality, Lesotho, total

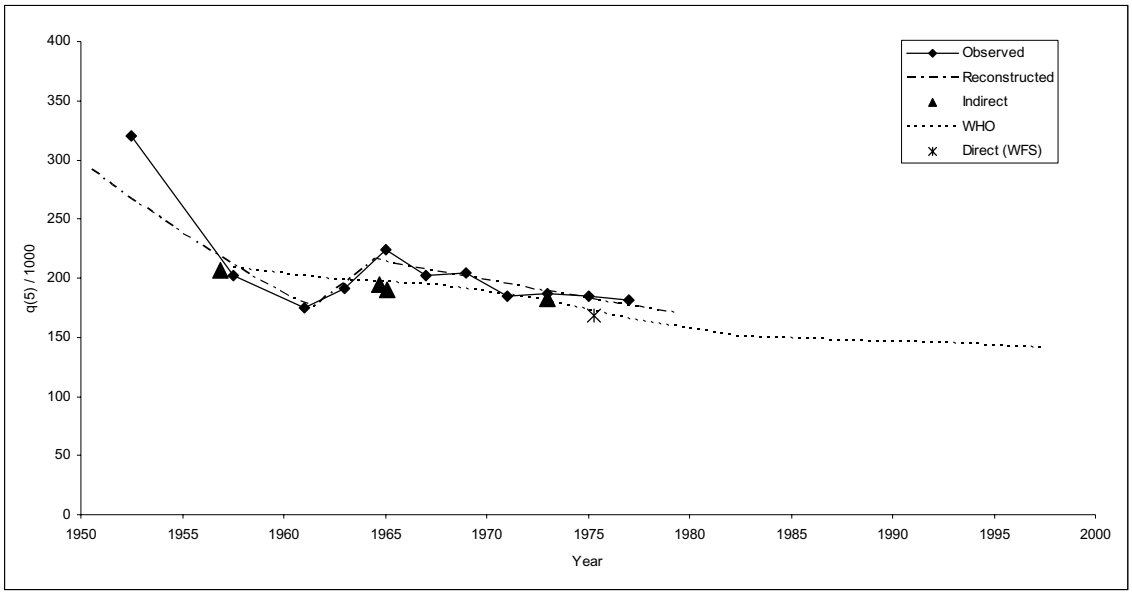
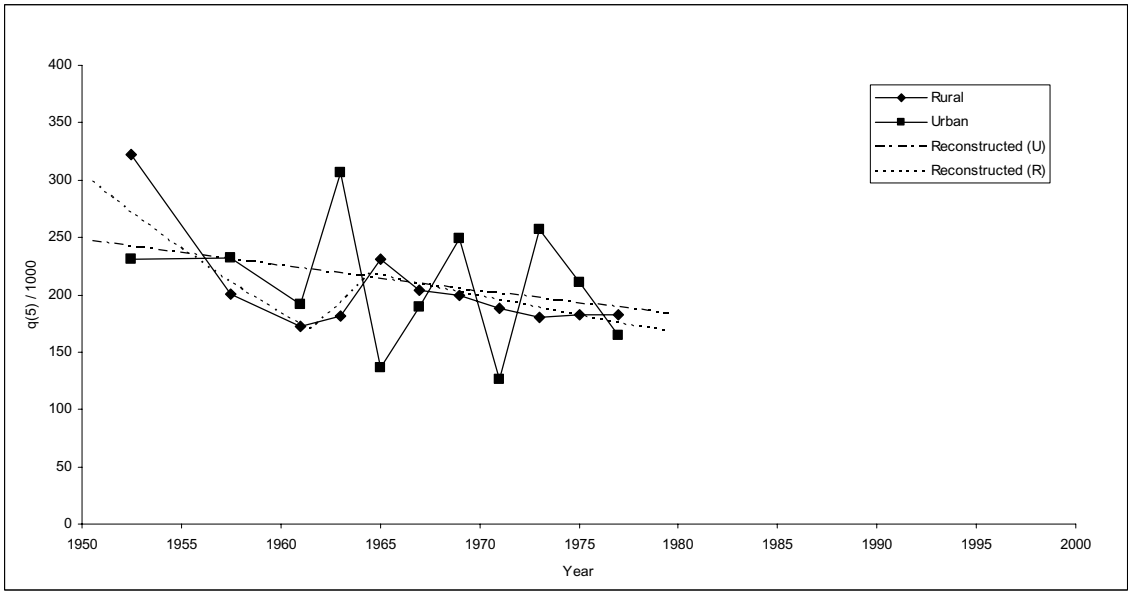


Figure 16b. Trends in under-five mortality, Lesotho, urban and rural



17. Liberia

Liberia conducted a DHS survey in 1986. The data are markedly consistent and show a steady decline in under-five mortality between 1950 and 1986, from 451 per 1,000 to 208 per 1,000. Reconstructed trends are different from the indirect estimates that are based on the 1970-71 Population Growth Survey. Under-five mortality decline was similar in urban and rural areas, with a gap of about 30 per 1,000. No data are available after 1986. The difficult political situation and the civil war in the 1990s suggest that favorable mortality trends did not continue into the recent period. Prevalence of HIV remained low in Liberia up to 2000, and probably had little effect on under-five mortality.

Figure 17a. Trends in under-five mortality, Liberia, total

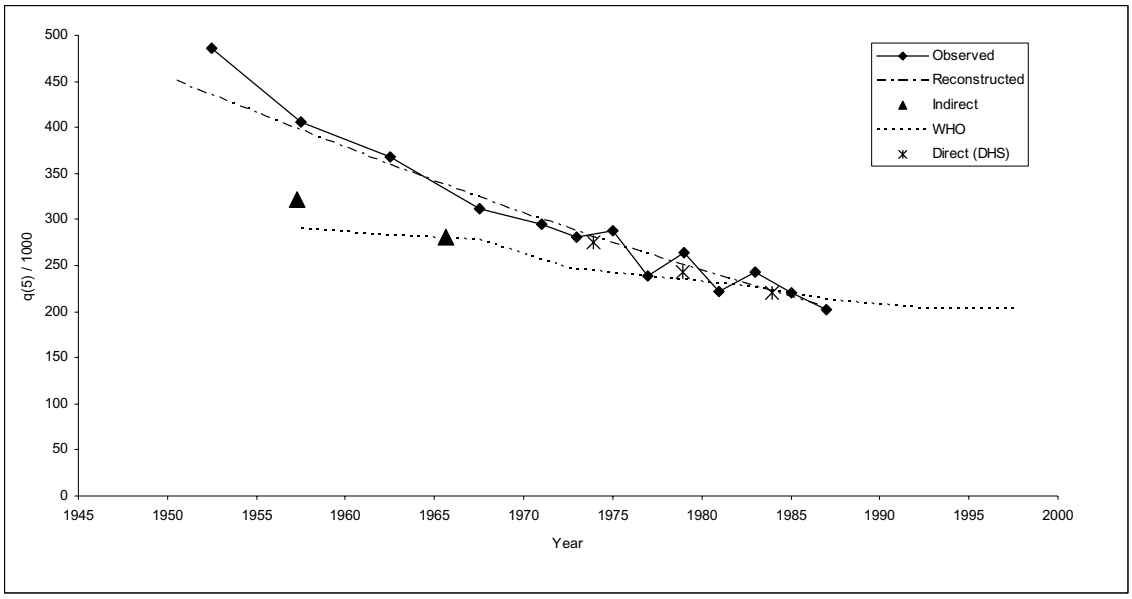
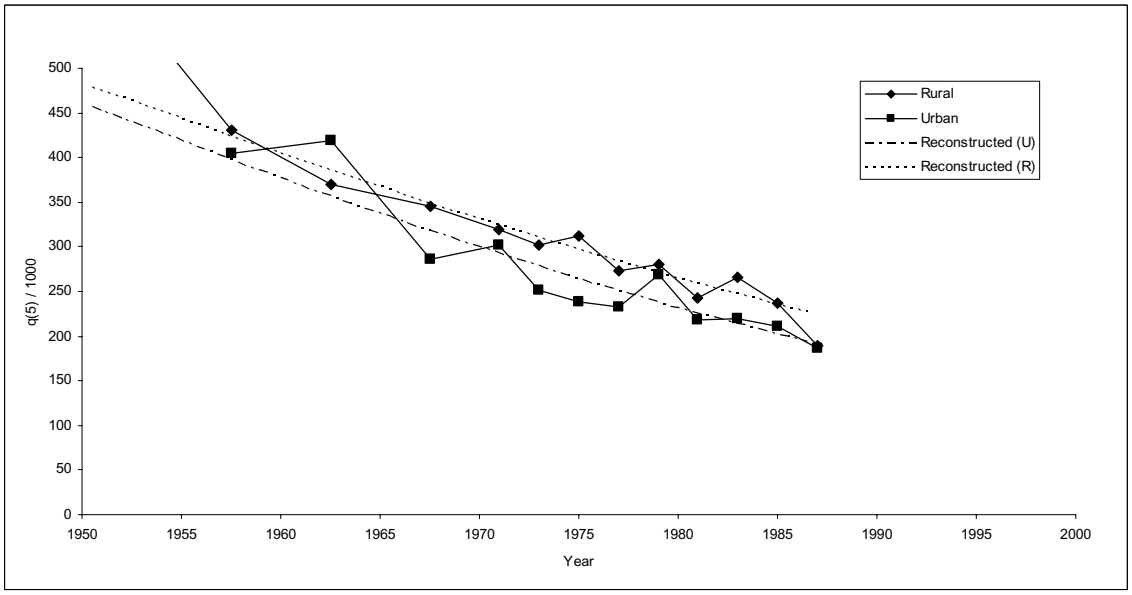


Figure 17b. Trends in under-five mortality, Liberia, urban and rural



18. Madagascar

Madagascar conducted DHS surveys in 1992 and 1997. These surveys are compatible, and both indicate a changing trend in under-five mortality between 1975 and 1986. Before 1975, mortality was declining steadily, from 285 per 1,000 in 1950 to 232 per 1,000 in 1960, although estimates before 1960 are less precise. Data from the 1966 Demographic Survey and the 1975 census—both based on deaths in the past 12 months—greatly underestimated mortality. Data from the 1972 vital registration, which covers primarily urban areas, also provide low estimates of under-five mortality. The period of rising mortality corresponds closely to that of the Marxist government, the Malagasy revolution (1973-85). It was followed by a period of rapid recovery, and by 1997 under-five mortality had fallen to 142 per 1,000, though still above what would have been expected from 1960-72 trends (100 per 1,000 by 1997). The WHO estimates smooth out the crisis period, while the DHS survey direct estimates document it properly.

Figure 18a. Trends in under-five mortality, Madagascar, total

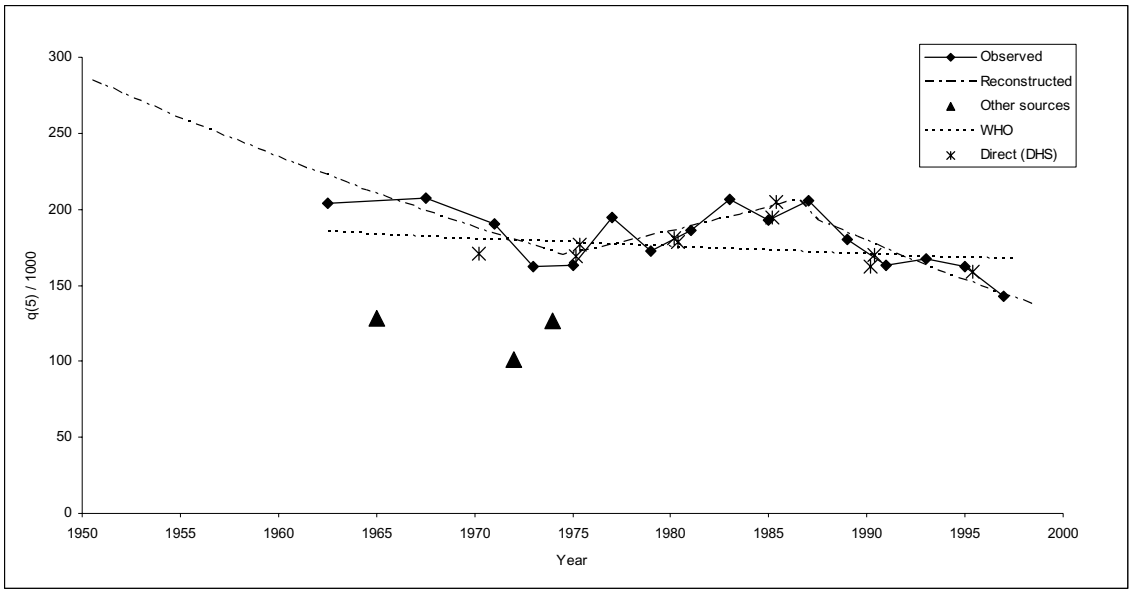
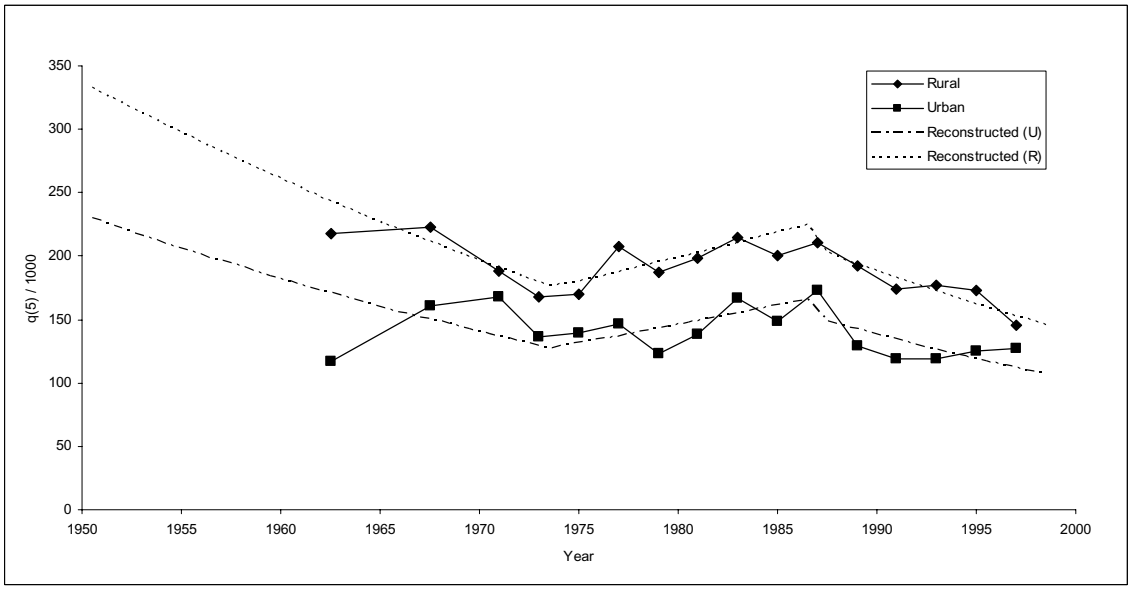


Figure 18b. Trends in under-five mortality, Madagascar, urban and rural

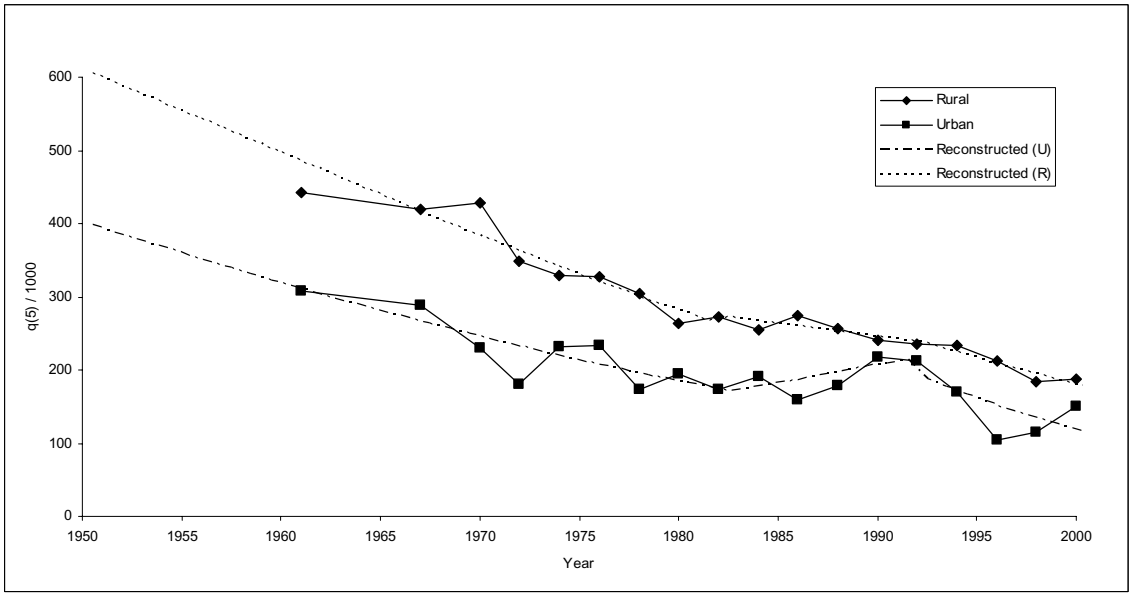


19. Malawi

Malawi is an exception in eastern and southern Africa because of the high levels of under-five mortality. Malawi conducted DHS surveys in 1992 and in 2000. Under-five mortality saw a dramatic decline from 1960 to 2000. The decline was rapid from 1960 (456 per 1,000) to 1982 (253 per 1,000), a slope of -3.8 percent; the decline was less pronounced from 1982 to 1991 (239 per 1,000, a slope of -1.5 percent). Then the decline was rapid again from 1991 to 2000 (169 per 1,000, a slope of -4.9 percent), with both changes in slope being highly significant ($P = 0.0007$ and $P = 0.0001$, respectively). The slower slope in the 1980s is due to a mortality increase in urban areas (from 171 to 215 per 1,000), while mortality continued to decline in rural areas (from 273 to 241 per 1,000). The 1979-80 point estimate is significantly lower ($P = 0.016$) than the reconstructed trend, which may mean that mortality declined somewhat faster at the end of the 1970s, and the period of mortality increase might have started in 1980; however, these differences remain small and do not affect interpretation. Under-five mortality trends were similar in urban and rural areas before 1982 and after 1991. Indirect estimates from the 1977 census and the 1996 KAP survey are compatible with the reconstruction, but not the indirect estimates for the 1970-71 Population Change Survey, which are underestimated. Projecting the 1960-81 trend backward predicts a mortality level of 550 per 1,000 in 1950, which is higher than previous estimates. Although this level of mortality remains plausible, the trend projection may have overestimated the mortality decline in the 1950s. WHO estimates tend to smooth out the mortality changes in Malawi and to underestimate the recent decline. Under-five mortality declined substantially in the 1990s despite the marked impact of pediatric AIDS, which was estimated at 45 per 1,000 in 2000. Without HIV/AIDS, the mortality decline in the 1990s would have been even more impressive.

Figure 19a. Trends in under-five mortality, Malawi, total

Figure 19b. Trends in under-five mortality, Malawi, urban and rural



20. Mali

Mali conducted DHS surveys in 1987, 1995, and 2001. The three surveys are compatible in levels and trends. Under-five mortality is high in Mali, although declining rapidly at a constant slope of -3.0 percent. Under-five mortality was estimated at 466 per 1,000 in 1960 and 202 per 1,000 in 2001. The only significant anomaly was lower mortality in 1983-84, a finding that is surprising because these were drought years in the Sahel. As in Malawi, projecting trends backward to 1950 might lead to an overestimation of mortality (542 per 1,000), although the predicted level remains plausible. The trends in under-five mortality were basically the same in urban and rural areas, although the speed of the decline was somewhat faster in rural areas (slope = -3.1 percent) than in urban areas (slope = -2.4 percent), and the difference was significant (P = 0.003). A survey conducted in 1960-61 in the Niger delta (a wealthier part of the country) reported a lower level of mortality than the national average. The prevalence of HIV/AIDS was moderate over the period covered, with the net impact of pediatric AIDS estimated at 17 per 1,000 in 2000. Thus, pediatric AIDS had only a small effect on under-five mortality.

Figure 20a. Trends in under-five mortality, Mali, total

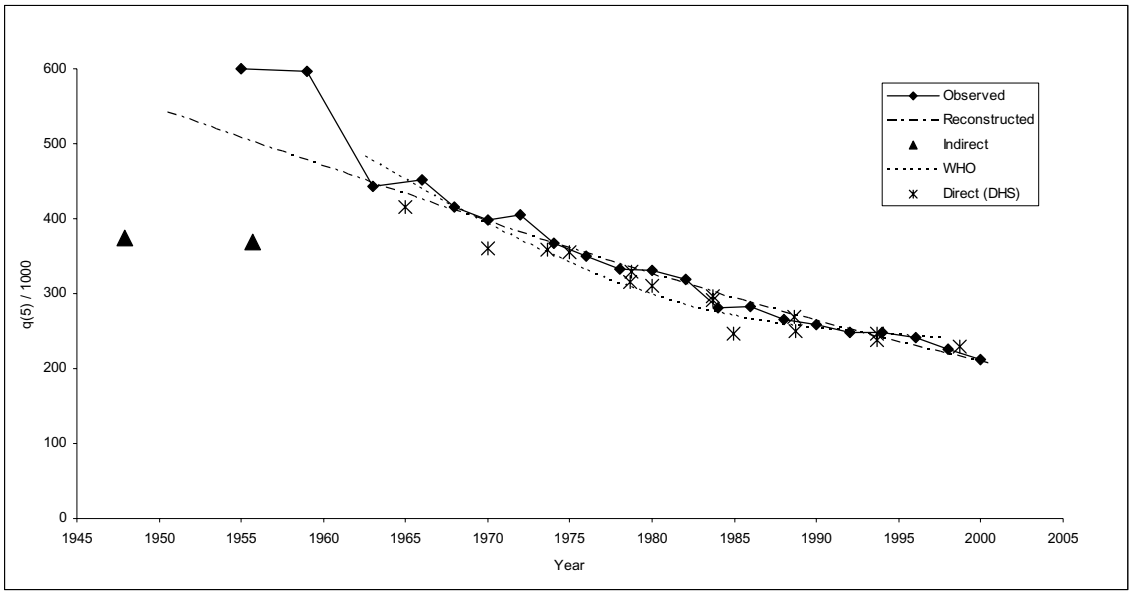
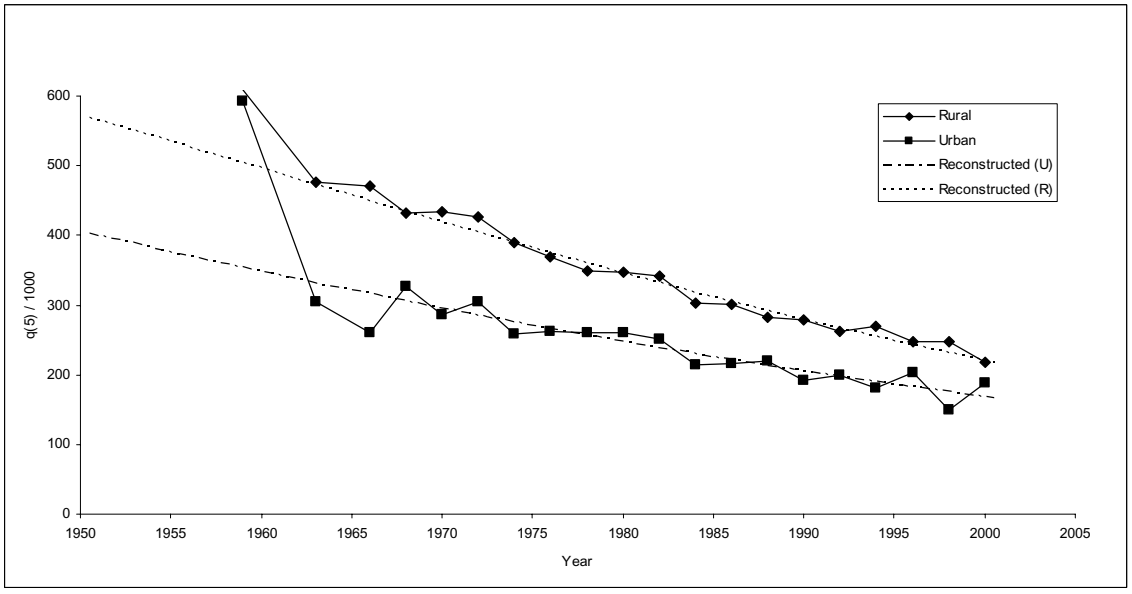


Figure 20b. Trends in under-five mortality, Mali, urban and rural



21. Mozambique

Mozambique conducted a DHS survey in 1997. This survey allowed us to reconstruct mortality trends during the troubled civil war period. Under-five mortality was declining fast at the end of the colonial period and the beginning of the independence period, declining from 280 per 1,000 in 1970 to 181 per 1,000 in 1981. Under-five mortality underwent a rapid increase during the main part of the civil war, reaching 262 per 1,000 in 1991. Thereafter, it declined to 158 per 1,000 in 1997. Data are lacking for the period before 1970, however, as in Angola, the early Portuguese censuses for 1940, 1950, and 1970 provided some estimates of under-five mortality, but they are inconsistent (280, 335, and 223 per 1,000, respectively). A study conducted by Don Heisel (Heisel, 1968) estimated the level of mortality to be between 271 and 367 per 1,000 in the years before 1950, and he estimated life expectancy at 32 years, which corresponds to under-five mortality of 340 per 1,000 in a model life table system. Looking at later trends, these values still are underestimated, unless mortality rose or was steady during the 1950-70 period. To reconstruct the trends, we have arbitrarily assumed a steady decline of mortality from 400 per 1,000 in 1950 to 280 per 1,000 in 1970, a slope of -2.7 percent, which is realistic. This period is, however, not based on empirical data. During the reconstructed period (1970-97), urban and rural trends were complex. No obvious difference in mortality existed before 1975, then a major increase occurred in rural areas while urban areas stagnated until 1991. Mortality in the two areas converged again between 1991 and 1997, as a result of the rapid decline in mortality in rural areas. Differences in slopes between urban and rural areas were all significant. The complex changes in mortality by residence can be explained by the dynamics of the civil war. The rebel movement, RENAMO, controlled a large part of the countryside, and had a strategy to destroy the state infrastructure, in particular schools and health centers. In contrast, the party in power in Maputo, FRELIMO, concentrated all its investments and services in urban areas. The small gap in mortality between urban and rural areas before and after the war is notable, and is found in only a few other countries in Africa. The impact of pediatric AIDS is still low in Mozambique, and was estimated to be 10 per 1,000 in 1997. It could increase in the coming years unless proper action is taken. Pediatric AIDS explained only one-third of the mortality increase in urban areas between 1991 and 1997 (+25 per 1,000 because of HIV/AIDS for a total increase of +78 per 1,000).

Figure 21a. Trends in under-five mortality, Mozambique, total

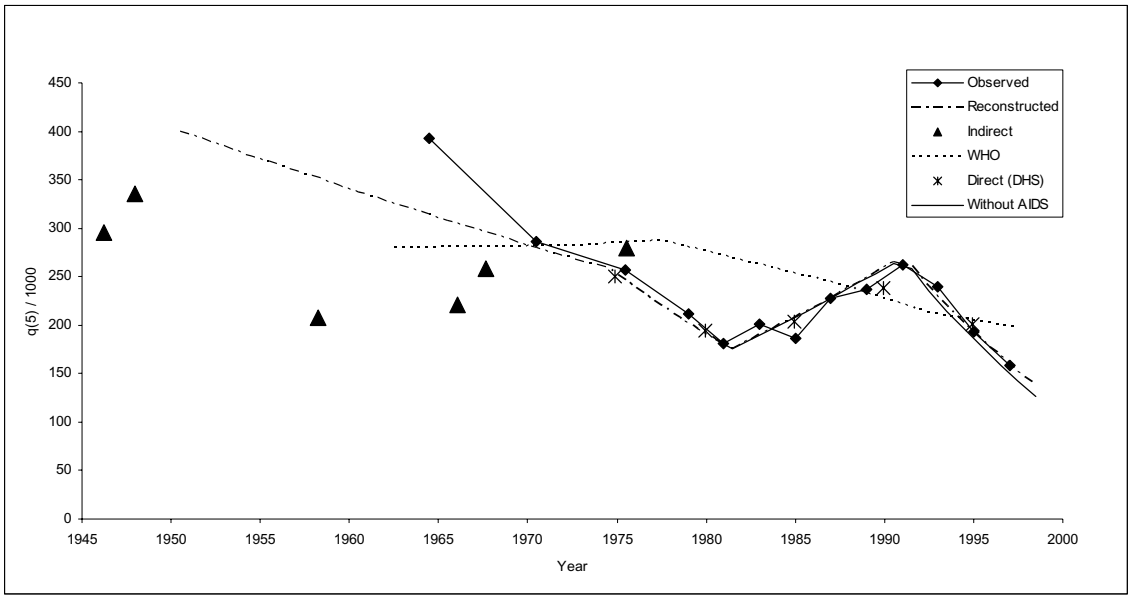
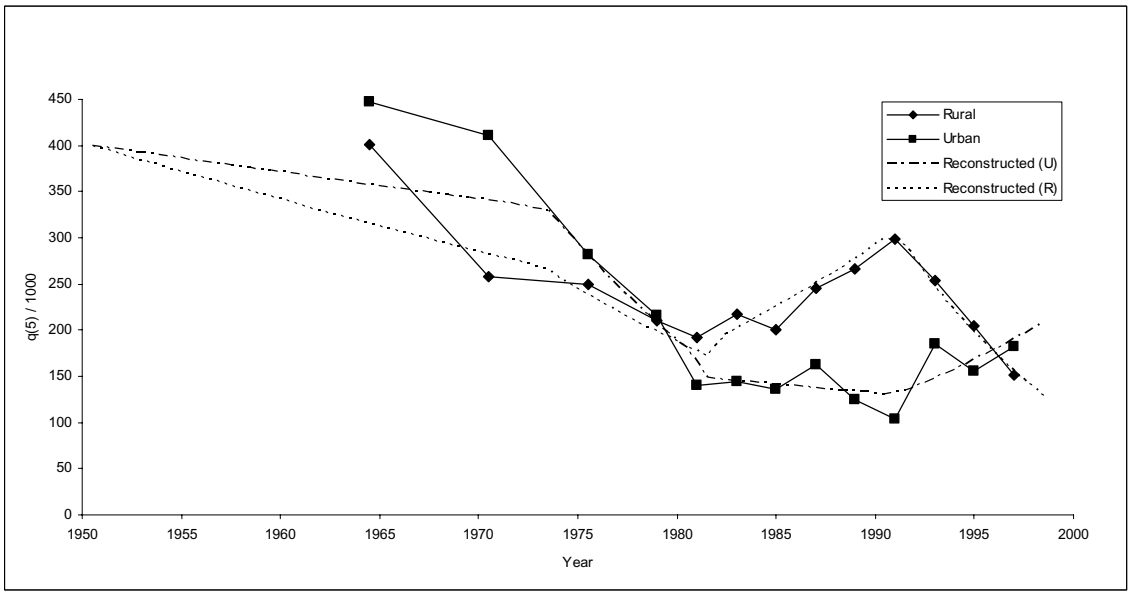


Figure 21b. Trends in under-five mortality, Mozambique, urban and rural



22. Namibia

Namibia conducted DHS surveys in 1992 and 2000. The second survey produced somewhat lower estimates of under-five mortality and smaller slopes for trends. An average of the mortality levels from the two surveys was considered the most reliable estimate, with somewhat higher values in 1992 and somewhat lower values in 2000 for unknown reasons. The combined estimates indicate a mortality decline from levels that were already quite low (161 per 1,000 in 1960); however, trends over the period 1960-2000 are complex. Mortality declined between 1960 and 1975 in both urban and rural areas. Then, it rose from 100 to111 per 1,000 during the period 1975-80 when the struggle for independence was occurring (as in Zimbabwe). The increase in mortality during this period was significant only in rural areas; in urban areas the mortality decline simply stopped. Because of the small sample size, changes in slopes are significant only in the rural areas (P = 0.023 in rural areas, and 0.189 in urban areas). This short period of increasing mortality was followed by a period of rapid decline that reached 52 per 1,000 in 1996. Finally, mortality increased again, reaching 70 per 1,000 in 2000. This increase was most likely due to HIV/AIDS. AIDS was negligible in Namibia until 1992, but played a larger role in 2000 (36 per 1,000).

Figure 22a. Trends in under-five mortality, Namibia, total

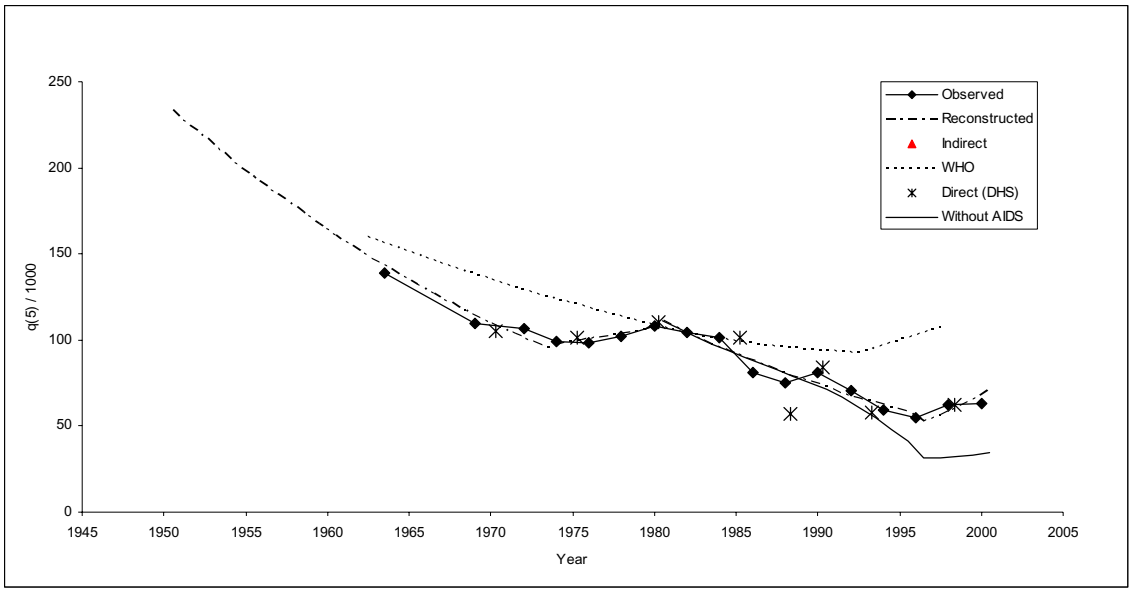
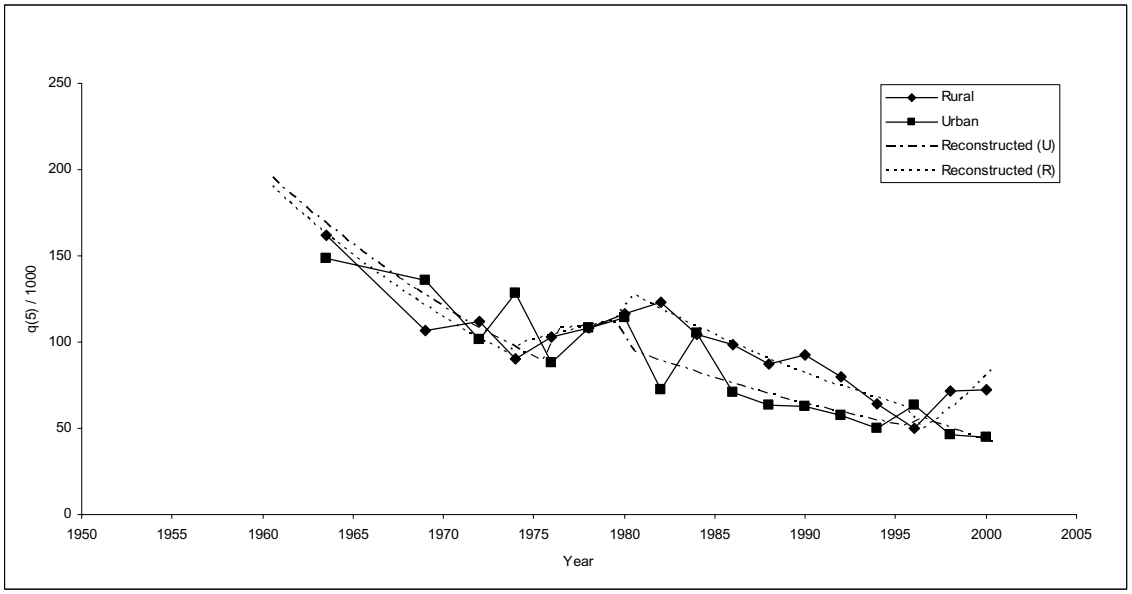


Figure 22b. Trends in under-five mortality, Namibia, urban and rural



23. Niger

Niger conducted DHS surveys in 1992 and 1998. Both surveys are consistent in levels and trends. They show a steady decline in under-five mortality from 449 per 1,000 in 1958 to 340 per 1,000 in 1972. This period was followed by a period of stagnation until 1992. A renewed decline in mortality took place between 1992 and 1998, reaching 187 per 1,000 by the end of the period. The stagnation in the years 1972-92 occurred because of a slight increase in mortality in rural areas, while mortality continued to decline in urban areas. The gap in mortality between urban and rural areas in the 1980s increased, reaching a high of 182 per 1,000 in 1992 and then decreased significantly in the following years. Levels of under-five mortality remain high in Niger, among the highest in sub-Saharan Africa, and the gap between urban and rural areas remains large, although it has diminished somewhat. There is little comparative data available for Niger. The 1959 INSEE survey substantially underestimated mortality. The impact of AIDS is negligible in Niger, and was estimated at 3 per 1,000 in 1998.

Figure 23a. Trends in under-five mortality, Niger, total

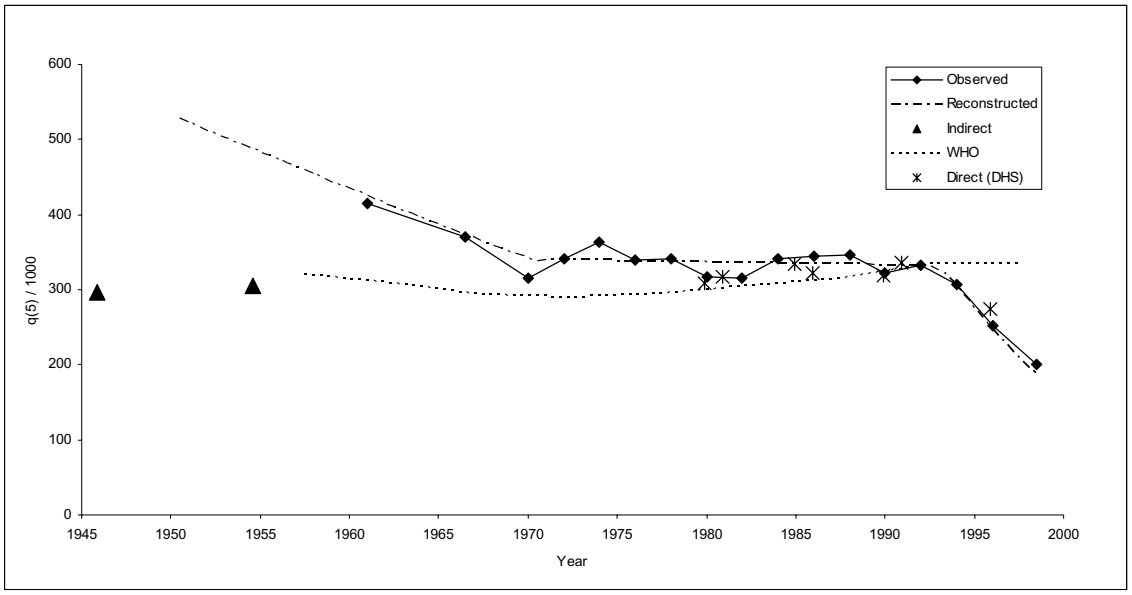
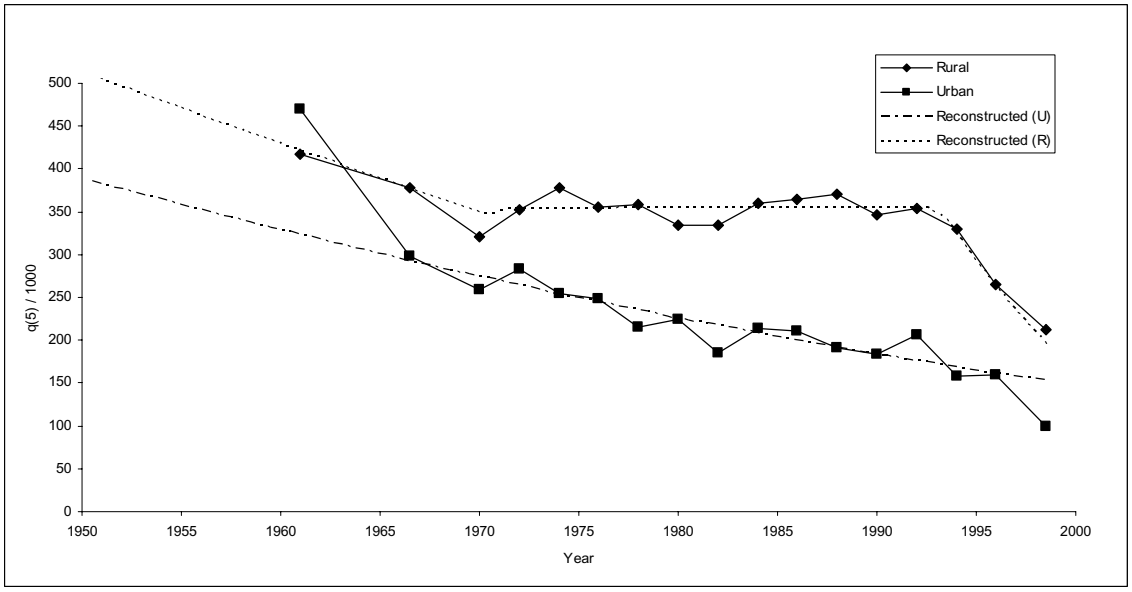


Figure 23b. Trends in under-five mortality, Niger, urban and rural



24. Nigeria

Nigeria conducted a WFS survey in 1982 and DHS surveys in 1990 and 1999. The three surveys are not always compatible, and gaps between under-five mortality estimates are as high as 50 per 1,000. The WFS survey particularly tends to underestimate mortality for the 1965-75 period, and the 1990 DHS survey gives higher mortality levels for the 1975-89 period. However, the 1982 and 1999 surveys are compatible for the 1972-80 period. The reasons for these discrepancies, unique among the countries in this analysis, remain unclear. Errors in data collection or erratic patterns caused by sampling schemes could be the causes, however there is no proof for these theories. The combined group of three surveys is, however, more stable, and indicates a series of complex changes in under-five mortality. Death rates declined rapidly between 1950 (325 per 1,000) and 1964 (207 per 1,000), and then rose for four years (239 per 1,000). This period covers the time of the Biafra war. Mortality decline resumed after the war, reaching 172 per 1,000, then it stagnated and even increased slightly for about 10 years until 1987 (183 per 1,000). From 1987 to 1999, mortality declined steadily and reached 113 per 1,000 in 1999. All the changes in slopes are highly significant. Mortality trends were generally parallel in urban and rural areas. In 1964-68, the increase in mortality was concentrated in urban areas, while in 1977-83 it was concentrated in rural areas. Then in 1988-89 the trend in the mortality decline shifted again and was more pronounced in rural areas than urban areas, so the gap between the two trend lines was reduced by half, from 83 to 40 per 1,000. Pediatric AIDS had a small impact over the period, estimated at 10 per 1,000 in 1999. Its impact could increase in the near future. The main issue in interpreting the Nigerian data remains the uncertainty about data quality. Some of our estimates are compatible with other sources, direct and indirect, but others are not. Some of the other sources are also inconsistent. Also, the overall pattern could be interpreted as a steady mortality decline over the entire 1950-99 period, with large fluctuations as a result of some erratic data.

Figure 24a. Trends in under-five mortality, Nigeria, total

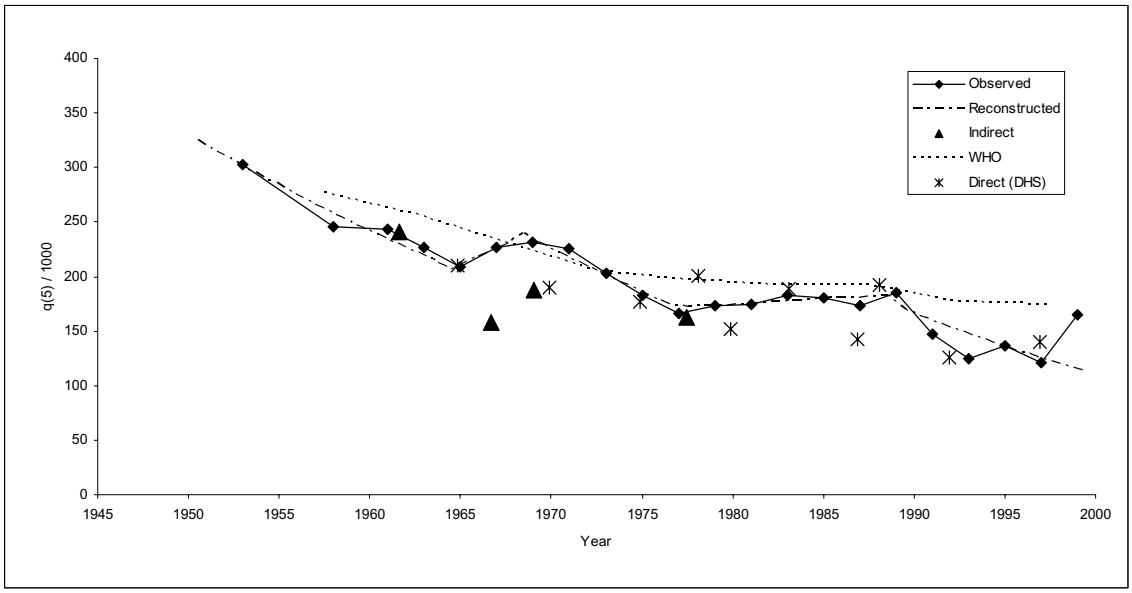
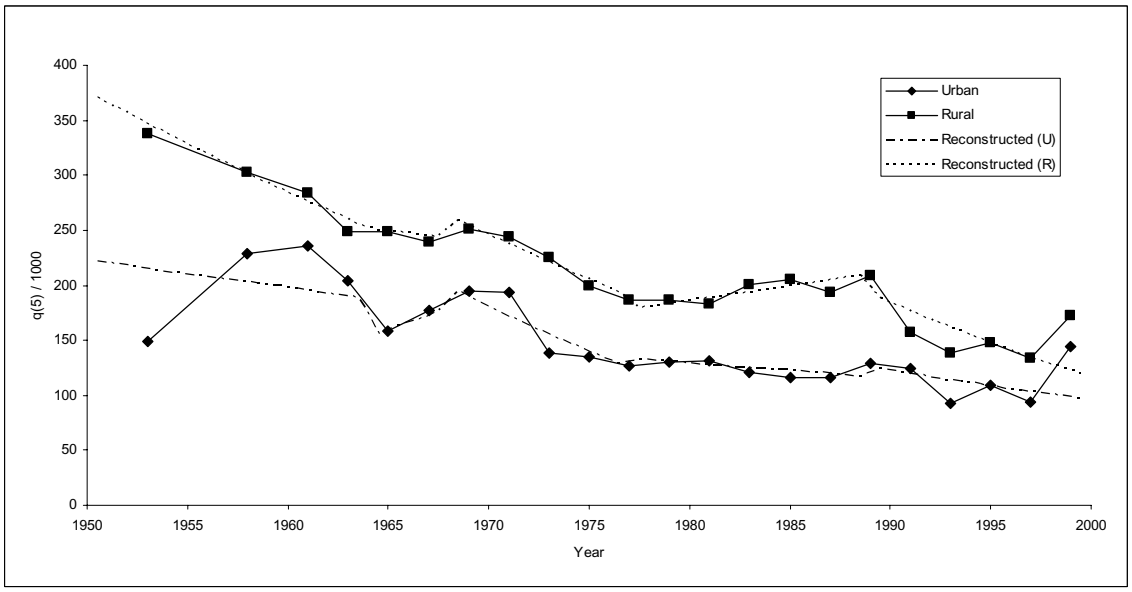


Figure 24b. Trends in under-five mortality, Nigeria, urban and rural



25. Rwanda

Rwanda conducted a WFS survey in 1983, and DHS surveys in 1992 and 2000. All three surveys are compatible in levels and trends, despite the complex history of changes in under-five mortality. Combined data indicate several monotonic periods and a succession of major anomalies in recent years. Under-five mortality declined between 1950 (346 per 1,000) and 1965 (229 per 1,000). Then it increased for 12 years, reaching 261 per 1,000 in 1977. This period was followed by a rapid decline until 1990 (132 per 1,000). The picture thereafter is complicated by the war, genocide, and the difficult recovery period that followed. Under-five mortality had already started to increase in 1991-92 and peaked in 1994, the year of the genocide (308 per 1,000). It declined again to 187 per 1,000 in 1996, then increased to 232 per 1,000 in 1998. In 2000, under-five mortality had declined to 142 per 1,000. It should be noted that the 1990s in Rwanda were an unusual time, and concepts of the health transition and regular mortality trends do not apply. For this reason, we do not present trends for this period. It should also be pointed out that the mortality data presented in this report underestimate the mortality over the period of the genocide because Tutsi families that were decimated could not be interviewed in 2000 and many Hutu refugees who left the country in 1994 did not return. The figures presented are thus showing only a net effect for the surviving population who stayed or immigrated to Rwanda since 1994. The country had not had time to fully recover by 2000, and under-five mortality was still far above the level expected from the 1950-65 trend (71 per 1,000), a measure of what could have been the health transition if the political situation had permitted. Trends were similar in urban and rural areas, with similar rises and falls and similar erratic patterns in the 1990s. The difference in slopes in the 1950s has been attributed to the small numbers of deaths in urban areas, and is not significant. However, in the period 1977-90, mortality declined more rapidly in rural areas than in urban areas ($P = 0.0001$), so that urban and rural mortality were at the same level in 1990. Indirect estimates were compatible with the reconstruction, except for the data from the 1970 survey, which underestimated mortality. The impact of AIDS is moderate in Rwanda, and was estimated at 32 per 1,000 in 1990 and 27 per 1,000 in 2000. A decline in seroprevalence among pregnant women is thought to account for the decline in pediatric AIDS.

Figure 25a. Trends in under-five mortality, Rwanda, total

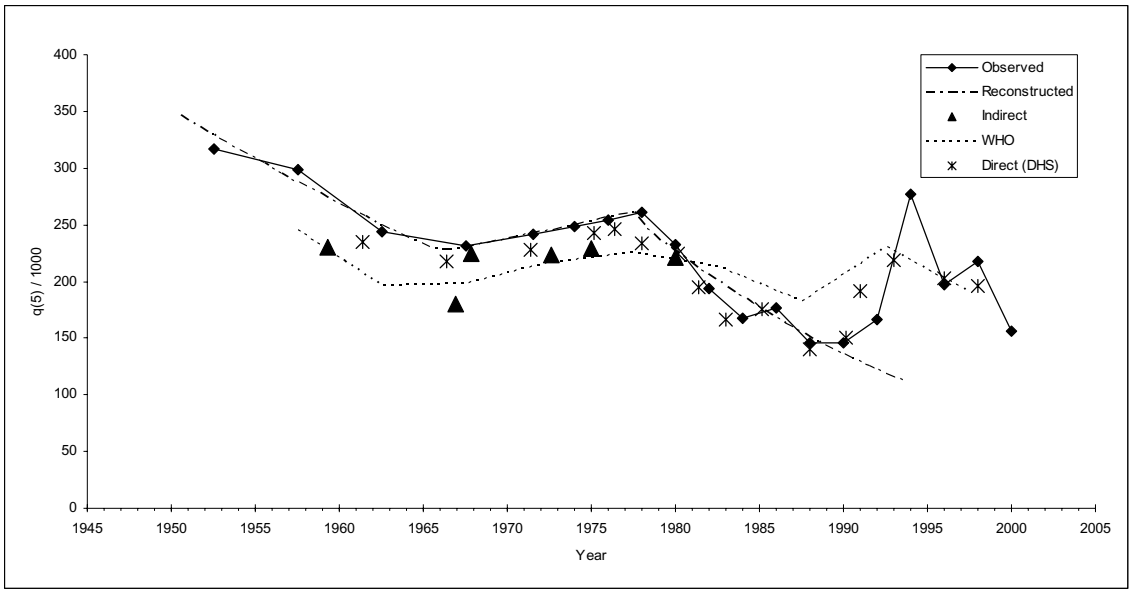
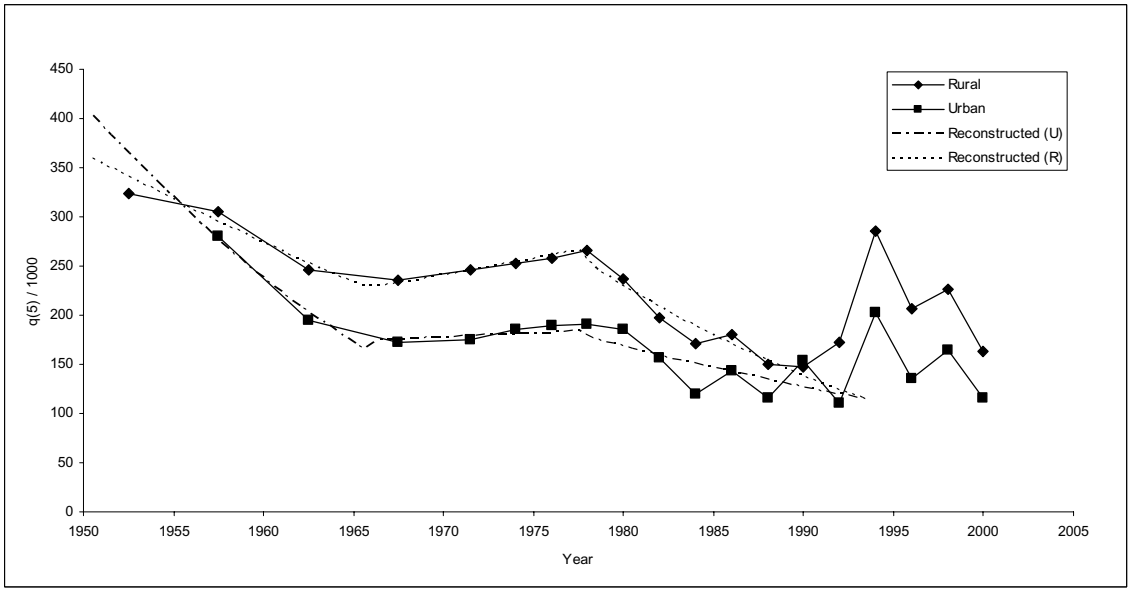


Figure 25b. Trends in under-five mortality, Rwanda, urban and rural



26. Senegal

Senegal has a wealth of high-quality demographic data: a WFS survey conducted in 1978 and DHS surveys conducted in 1986, 1993, and 1997. The data from the four surveys are markedly consistent in levels and trends of under-five mortality. The 1950-97 years could be divided into three monotonic periods: a rapid decline in mortality throughout the 1950s, from 394 per 1,000 in 1950 to 285 per 1,000 in 1959; a period of slow increase in mortality in the 1960s, reaching 309 per 1,000 in 1969; and then a long period of steady mortality decline. In addition, two minor anomalies could be noted: (1) excess mortality in 1974 ($P = 0.037$), which could be associated with the severe Sahelian drought, and (2) lower-than-expected mortality in 1988-89 ($P = 0.007$), which could be the result of the successful vaccination campaigns. The vaccinations markedly reduced transmission of and mortality from caused by measles and whooping cough and had an impact on neonatal tetanus, all major causes of death among children under five. The mid-90s (1994-97) saw a small increase in mortality (+23 percent, $P < 10^{-7}$), possibly a result of the return of communicable diseases following the decline in vaccination coverage, and the increase in mortality from chloroquine-resistant malaria. These variations were small compared with the substantial decline in mortality over the period. Indirect estimates are quite consistent with the reconstructed values, although estimates from the 1960-61 survey are low. A final point is abnormal: the last estimate of the WFS survey. Trends were similar in urban and rural areas in the 1940s, and then diverged markedly in the 1950s (205 per 1,000). The mortality increase in the 1960s lasted longer in rural areas (until 1969) than in urban areas (until 1966-67). Here again, mass vaccination campaigns for measles conducted in 1966-69 could explain the trends. The primary health care policy, which aimed at reducing the gap in mortality between urban and rural areas, was successful; the gap was reduced to 43 per 1,000 in 1997, about five times less than the gap was in the 1950s. The impact of HIV/AIDS remained negligible in Senegal and was estimated to be less than 2 per 1,000 in 1997.

Figure 26a: Trends in under-five mortality, Senegal, total

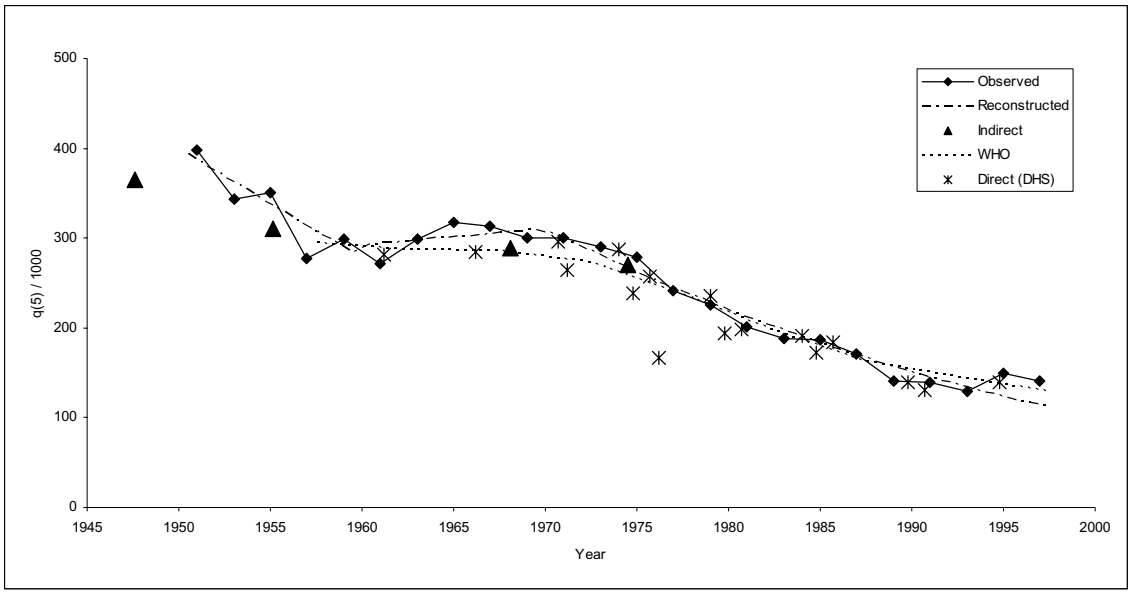
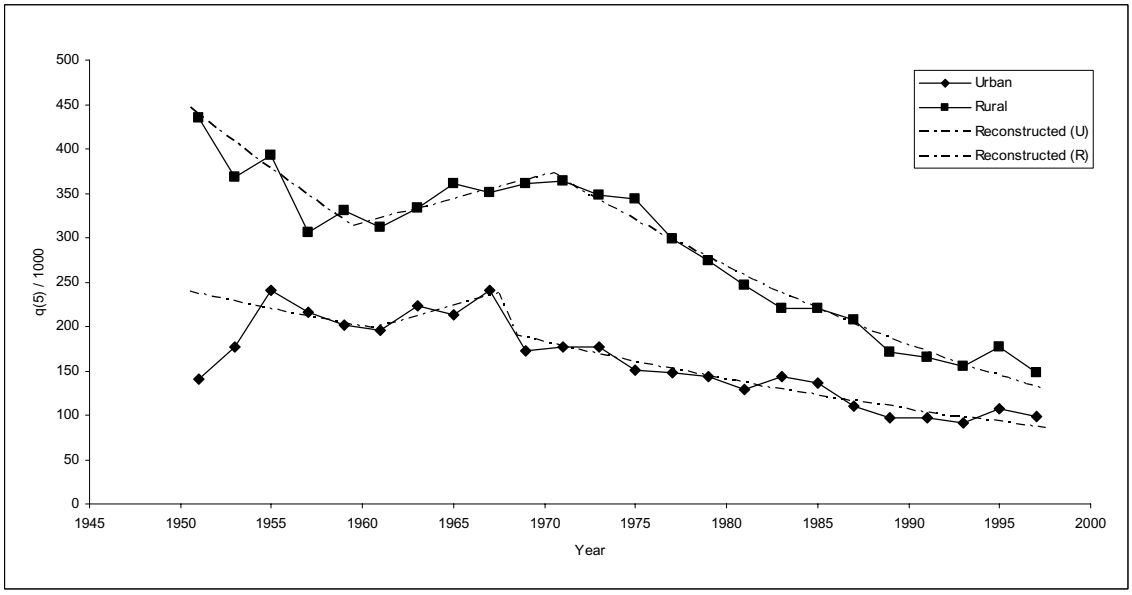


Figure 26b: Trends in under-five mortality, Senegal, urban and rural



27. South Africa

A DHS survey was conducted in South Africa in 1998. This survey allows the reconstruction of trends since the mid-1960s. From then until 1992, under-five mortality declined rapidly, at an average rate of -6.3 percent, from 188 per 1,000 in 1968 to 48 per 1,000 in 1992. This was one of the most rapid declines in mortality reported for Africa, and parallels major public health efforts during that period. However, mortality started to increase rapidly after 1993, at an average rate of +9.8 percent, reaching 74 per 1,000 in 1998. This level of under-five mortality is low for the continent as a whole. The increase in mortality was almost entirely due to HIV/AIDS. However, even after discounting for pediatric AIDS mortality, under-five death rates were stationary in South Africa, around 40 per 1,000, a finding that suggests that earlier progress in treating other early childhood causes of death were not sustained. The quality of HIV seroprevalence data is excellent in South Africa, and assuming that the parameters used in the projection model do apply, it can be concluded that South Africa faced two problems since 1993: the increase in HIV/AIDS mortality and the stagnation of the health transition for other causes of under-five mortality. It could be, however, that the impact of pediatric AIDS was underestimated. Under-five mortality trends were quite similar in urban and rural areas before 1991, and the difference between the two slopes was not statistically significant. Mortality started to increase in urban areas as early as 1991, and about two years later in rural areas. However, mortality increase with a slope of +3.0 percent occurred only in rural areas. It should be noted that the last points on this graph are based on a small number of deaths and the values of the slopes have relatively wide confidence intervals.

Figure 27.a Trends in under-five mortality, South Africa, total

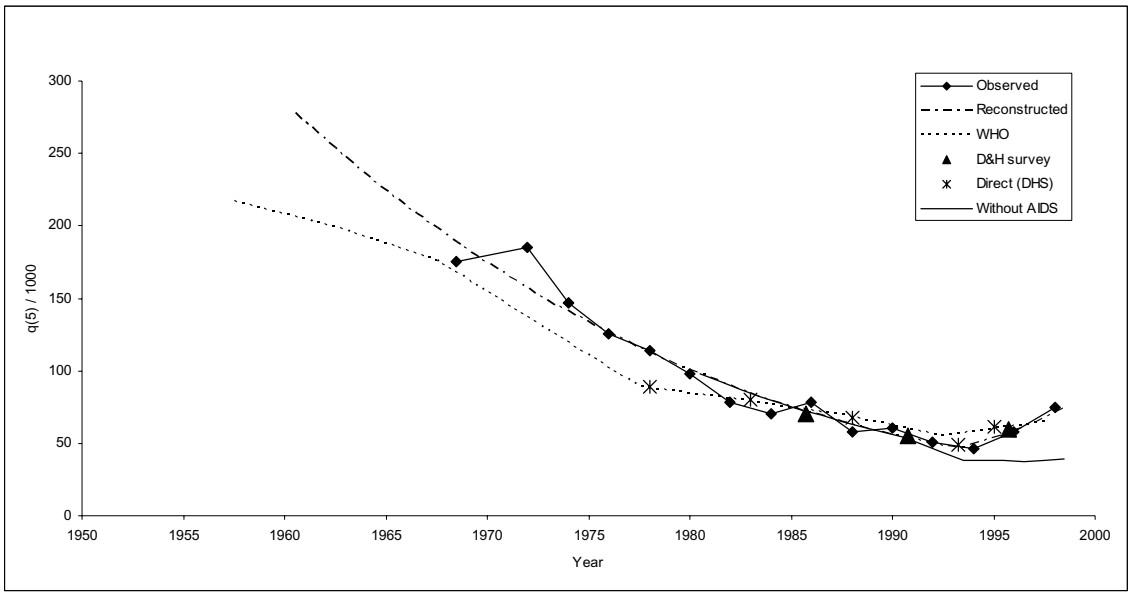
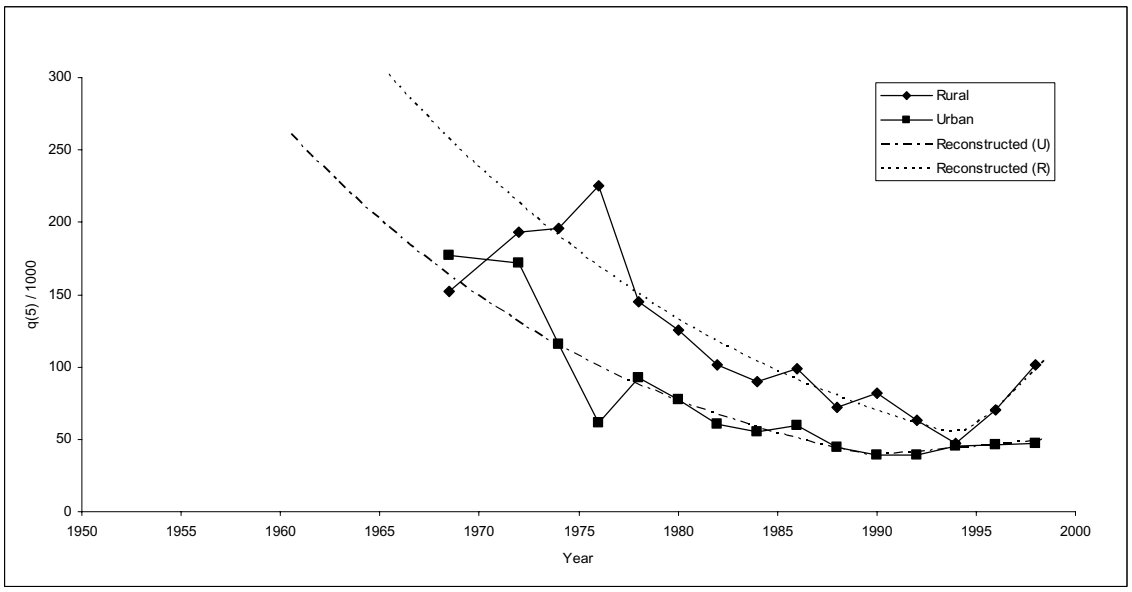


Figure 27b. Trends in under-five mortality, South Africa, urban and rural areas



28. Sudan

Sudan conducted a WFS survey in 1979 and a DHS survey in 1989. These surveys cover only the northern part of the country, and the 1989 survey deals only with ever-married women. Levels and trends in under-five mortality are compatible in both surveys. At baseline, under-five mortality was lower than elsewhere in Africa: 199 per 1,000 in 1950; thereafter it declined steadily until 1974 (143 per 1,000), stagnated for about 10 years at around 148 per 1,000, and then declined to 98 per 1,000 in 1990. Indirect estimates for northern Sudan from the 1973 census and from the household survey included in the WFS are compatible with our reconstruction. Mortality changes were parallel in urban and rural areas during the first period (1950-74); after that they diverged. There was a slight increase in rural areas between 1974 and 1986, while urban mortality continued to decline. In the last period, the gap in mortality between urban and rural areas decreased sharply, and at the end of the period mortality estimates in the two residence areas were virtually identical (110 and 112 per 1,000, respectively). The impact of HIV/AIDS was negligible in northern Sudan. HIV seroprevalence among pregnant women was below 1 percent until 1999.

Figure 28a: Trends in under-five mortality, Sudan (North), total

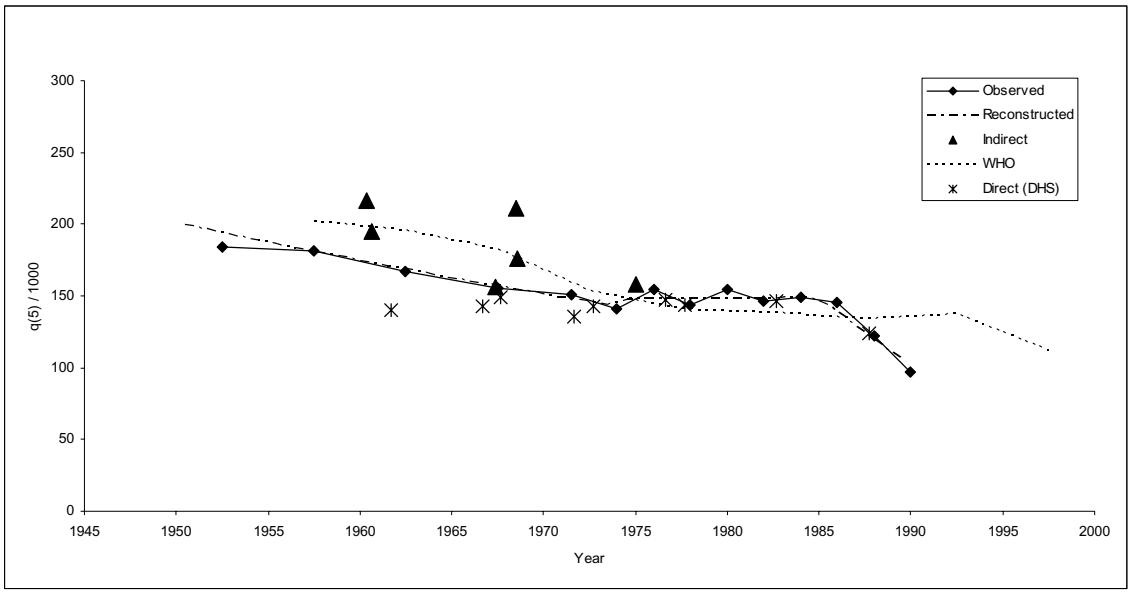
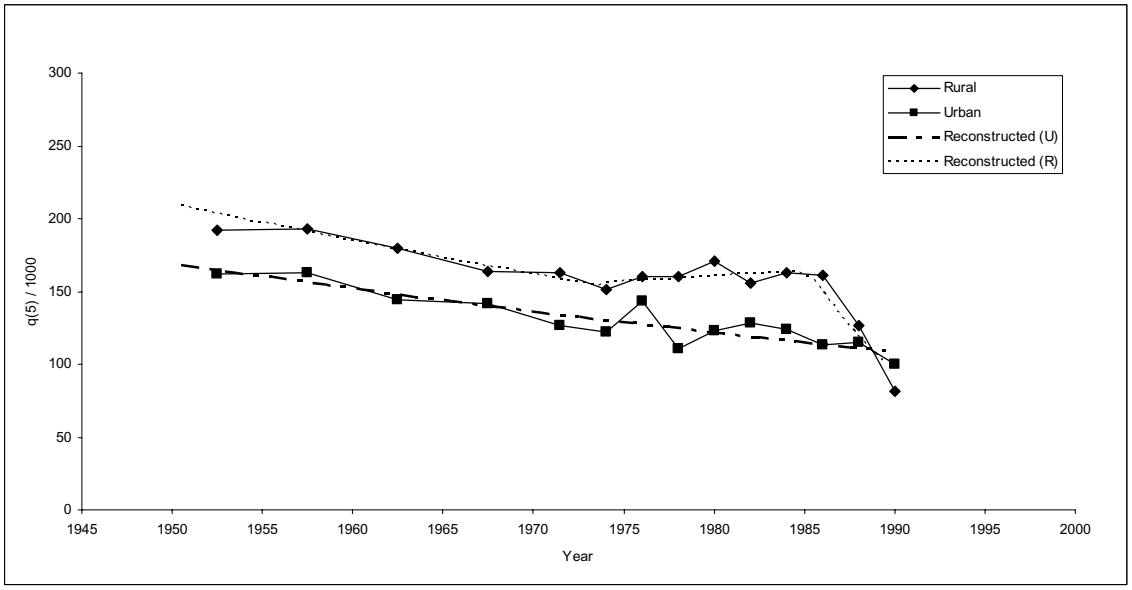


Figure 28b: Trends in under-five mortality, Sudan (North), urban and rural



29. Tanzania

Tanzania conducted DHS surveys in 1991 and 1996. These surveys are compatible and show similar levels and trends. Trends in under-five mortality are presented for four monotonic periods: a rapid decline from 1957 to 1972 (from 301 to 210 per 1,000), an even faster decline from 1972 to 1979 (151 per 1,000), then an increase through 1985 (180 per 1.000), which was followed by a steady decline through 1996 (125 per 1,000). All changes in slopes are highly significant, including the change in slope between the first and second period ($P = 0.015$). These changes were present in both urban and rural areas, except that the increase in mortality occurred earlier and lasted longer in urban areas (1978-87) than in rural areas (1982-85). As a result, differences in mortality between urban and rural areas, which were stable before 1978 (+38 per 1,000), vanished by 1986 and remained small until 1992 (+13 per 1,000). The gap increased again in the most recent years (+25 per 1,000). Pediatric AIDS is a major problem in Tanzania; without it, under-five mortality would have been 97 per 1,000 in 1996 instead of 125 per 1,000. The decline in under-five mortality from 1985 to 1996 would have been even more pronounced except for pediatric AIDS.

Figure 29a. Trends in under-five mortality, Tanzania, total

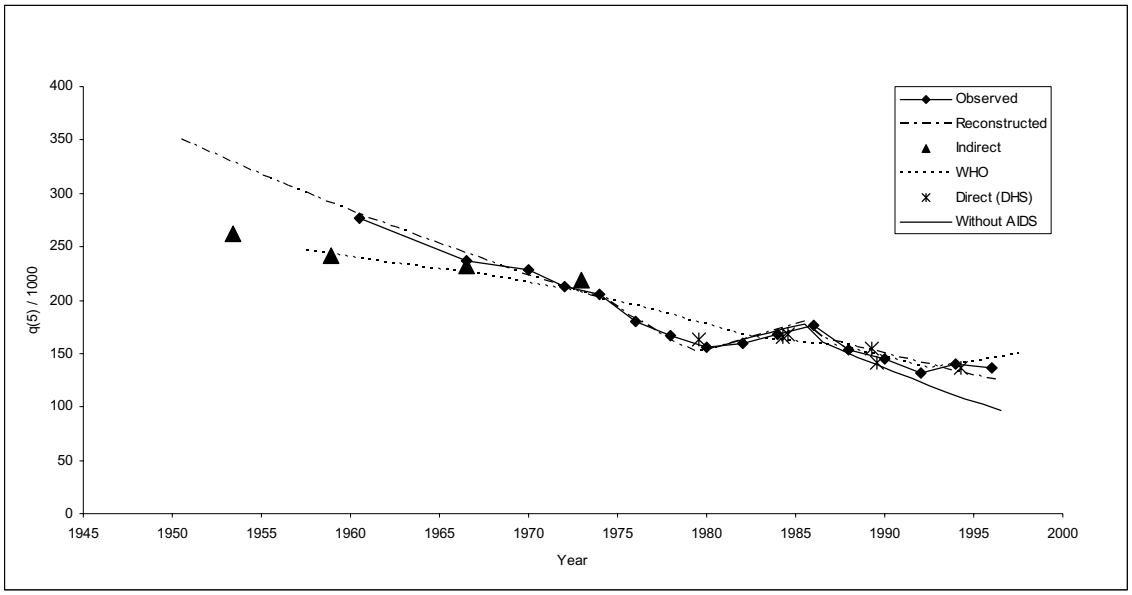
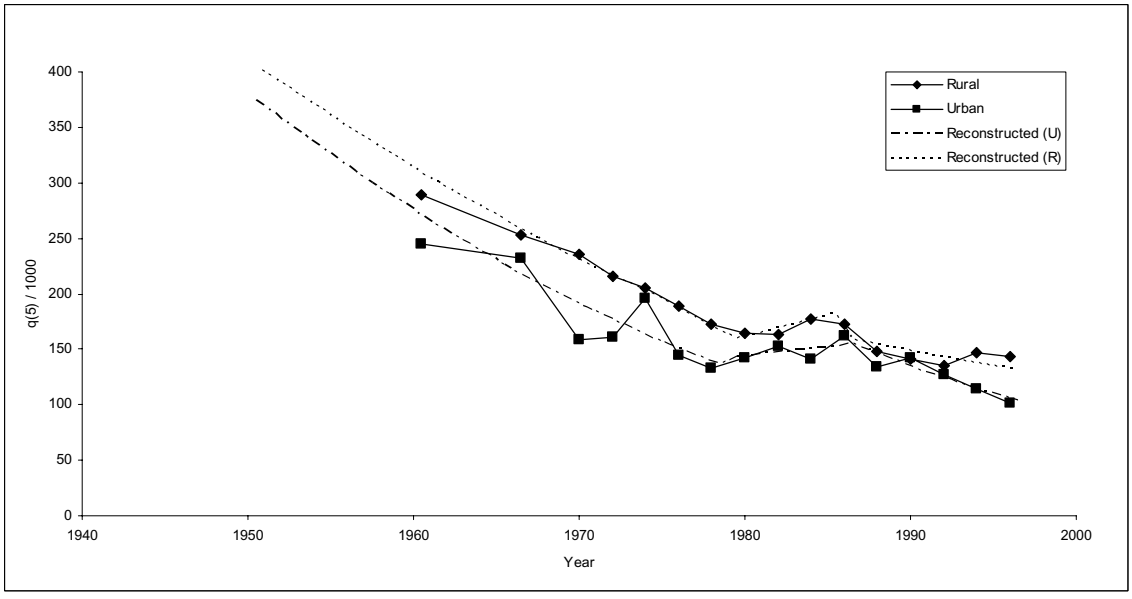


Figure 29b. Trends in under-five mortality, Tanzania, urban and rural



30. Togo

Togo conducted DHS surveys in 1988 and 1998. The two surveys are consistent in levels and trends of under-five mortality. They show a steady decline in under-five mortality from 299 per 1,000 in 1956 to 124 per 1,000 in 1998, with a relatively high slope (-2.6 percent). The decline in mortality is similar in urban and rural areas, although somewhat more rapid in rural areas (slope of -2.7 percent) than in urban areas (slope -2.1 percent), with the difference not being significant. As a result, the gap in mortality between urban and rural areas narrowed, from 113 per 1,000 in 1960 to 39 per 1,000 in 1998, and this difference is significant. Despite the steady decline in under-five mortality, a small anomaly was noted: excess mortality in 1993-94 that was highly significant ($P = 0.012$) occurred only in rural areas ($P = 0.003$). Indirect estimates derived from 1961 and 1971 surveys are consistent with the reconstruction in levels and trends. The impact of AIDS has been small in Togo, and was estimated at 10 per 1,000 in 1998.

Figure 30a. Trends in under-five mortality, Togo, total

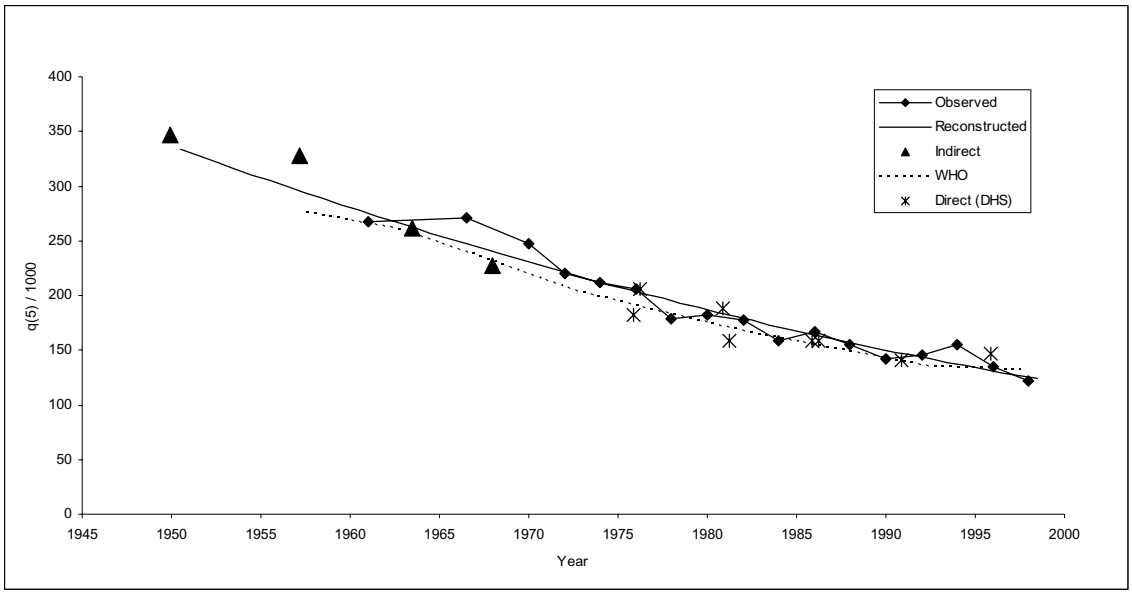


Figure 30b. Trends in under-five mortality, Togo, urban and rural

31. Uganda

Uganda conducted DHS surveys in 1988 and 1995; a third DHS survey was conducted in 2000, but the results were not yet available at the time of this analysis. Data from the two sources are fully compatible, and show the same levels and trends. Under-five mortality declined rapidly before 1971, from an estimated 330 per 1,000 in 1950 to 156 per 1,000 in 1970. Then mortality increased steadily for more than 10 years, reaching 206 per 1,000 in 1982-84. After 1985, mortality declined sharply. This crisis period corresponds to the period when Idi Amin Dada was in power (1971-79) and the ensuing troubled years. When Museveni took over in 1986, the situation was more favorable and permitted a catch-up from the crisis years. Recently published estimates from the 2000 DHS survey indicate that the favorable trend in under-five mortality continued through 1996-2000. The increase in mortality from 1971 to 1984 occurred in both urban and rural areas. The gap in mortality between urban and rural areas (77 per 1,000 before 1971 and 58 per 1,000 between 1971 and 1984) decreased substantially after 1985 (24 per 1,000). The reconstructed trends are compatible with the indirect estimates from the 1969 census. The impact of pediatric AIDS was noteworthy in Uganda, but the effect was limited compared with the level of under-five mortality. Pediatric AIDS deaths were estimated at 24 per 1,000, with a declining trend echoing the decline in HIV seroprevalence among pregnant women that began in the early 1990s. Without pediatric AIDS, the decline in under-five mortality in Uganda would have been even faster during the period 1986-92.

Figure 31a. Trends in under-five mortality, Uganda, total

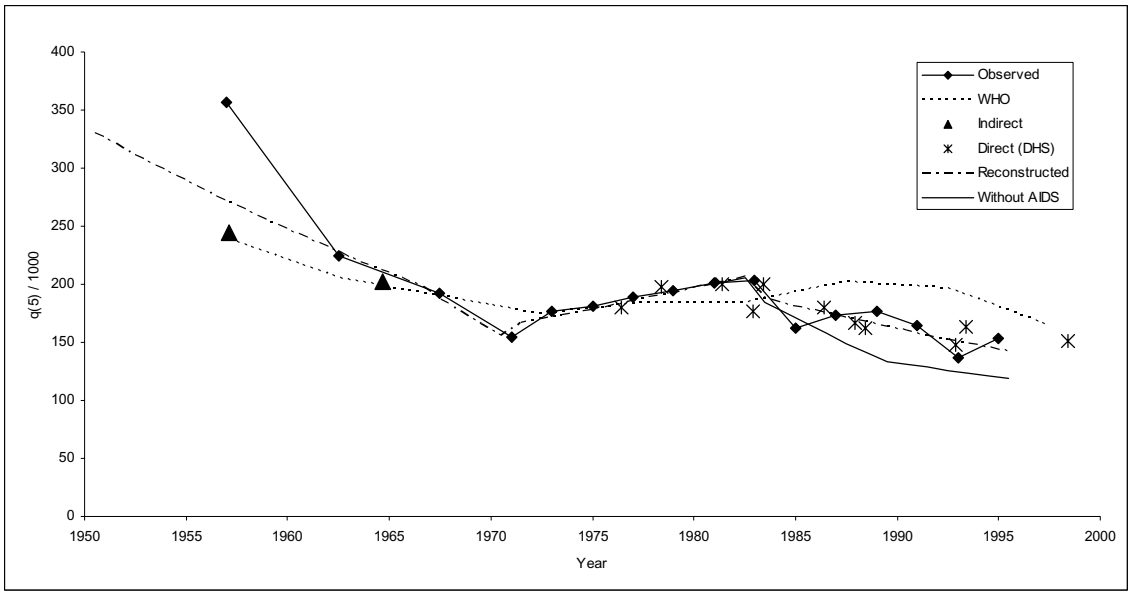
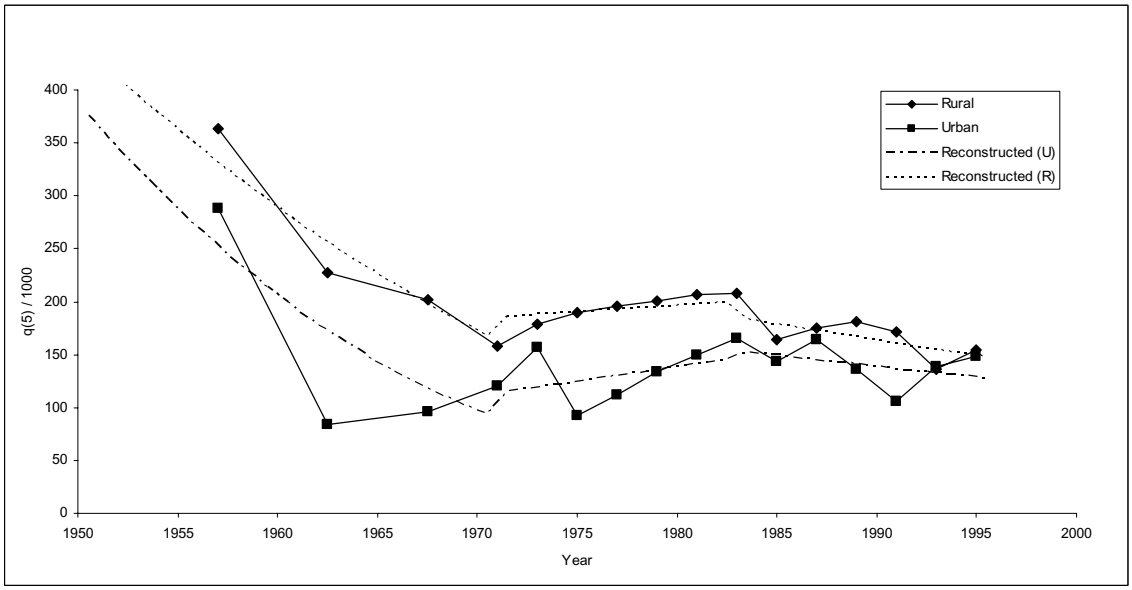


Figure 31b. Trends in under-five mortality, Uganda, urban and rural



32. Zambia

Zambia conducted DHS surveys in 1992, 1996, and 2001. All the surveys are compatible for levels and trends of under-five mortality. Together, the data indicate three main periods of monotonic change. First, there was a rapid decline in mortality from 1958 (335 per 1,000) to 1975 (150 per 1,000), averaging -6.1 percent per year. Then, mortality increased through 1992 (194 per 1,000) at an average rate of +1.8 percent. In the last period, mortality declined to 158 per 1,000 in 2001, at an average rate of -2.9 percent. Both changes in the slopes are highly significant ($P < 10^{-10}$ and $P = 5.6\ 10^{-8}$, respectively). Mortality in urban and rural areas shows the same pattern of change, with similar increases and declines. The decline in mortality was somewhat faster in urban areas from 1958 to 1975 ($P = 0.043$) and from 1975 to 1992 ($P < 0.0001$). The decline was significant in rural areas only from 1992 to 2001 (the slope was not different from 0 in urban areas). Some of the erratic patterns in the late 1950s and early 1960s were due to the small sample size for urban areas. Indirect estimates of mortality for the 1970s and 1980s are consistent with the reconstructed trends. They are, however, much lower than estimates for the 1950s and 1960s. This could be due to underestimation using indirect methods or overestimation using direct methods in the early years. Pediatric AIDS is a major problem in Zambia; it was estimated at 71 per 1,000 in 2000, or almost half (44 percent) of the total mortality. This finding emphasizes the heavy burden of pediatric AIDS in under-five mortality. Without AIDS, mortality decline would have been much greater since 1992 and would have been significant in urban as well as rural areas. The 1975-92 increase in under-five mortality is closely associated with the decline in copper prices on the international market in 1975—copper is Zamiba's main export commodity—and the severe economic crisis in the country thereafter. The recovery phase (discounting HIV/AIDS) is associated with the change in the political regime in 1992 and the reforms that followed.

Figure 32a. Trends in under-five mortality, Zambia, total

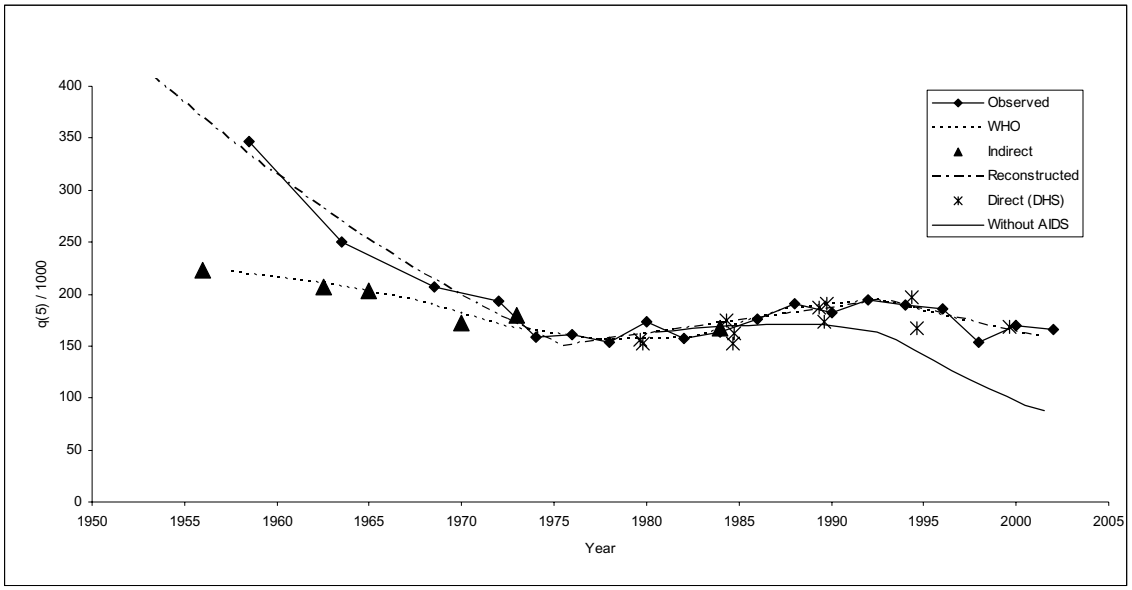
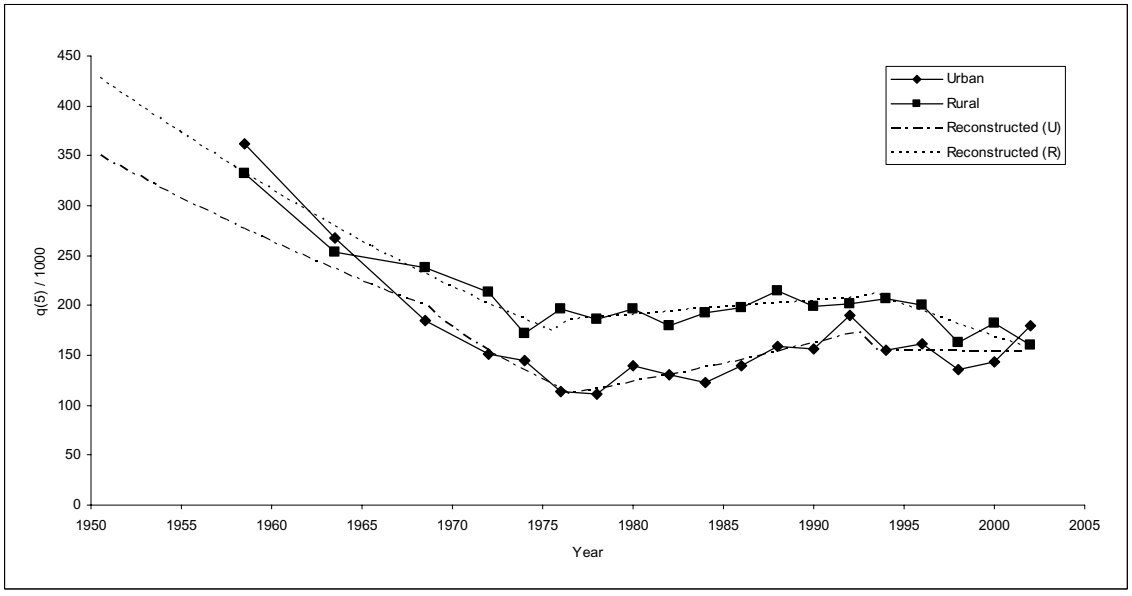


Figure 32b. Trends in under-five mortality, Zambia, urban and rural



33. Zimbabwe

Zimbabwe conducted DHS surveys in 1988, 1993, and 1999. The three surveys are compatible for levels and trends of under-five mortality. However, the 1999 data tend to push the 1978-82 peak in mortality two years forward. With this limitation, mortality trends in Zimbabwe can be examined for three periods: between 1956 (173 per 1,000) and 1975 (99 per 1,000) there was a steady decline in mortality with a slope of -3.4 percent; a short increase in mortality occurred in 1977-80 and was followed by a seven-year period of recovery; and then mortality increased sharply in 1987. Trends in under-five mortality were similar in urban and rural areas and differences between the slopes were not statistically significant. The peak in mortality in 1977-82 was more pronounced in rural areas, although it was also evident in urban areas. The increase in mortality in 1987-99 was stronger in urban areas (slope of +7.0 percent) than in rural areas (slope of +4.7 percent). So, by 1998-99, mortality was almost the same in both urban and rural areas (106 and 109 per 1,000, respectively). The first peak in mortality (1978-82) was associated with the struggle for independence and the difficult period that followed; it shares some similarities with events in Namibia. The substantial increase in mortality since 1987 is almost entirely due to AIDS. Zimbabwe was one of the hardest-hit countries in Africa, and the impact of pediatric AIDS was estimated at 76 per 1,000 in 1999. If the impact of AIDS is removed, the trend in under-five mortality after 1987 generally follows the earlier trend in 1982-87, with a highly negative slope (-5.7 percent) similar to that of the years before 1978. Indirect estimates of the 1950s and 1960s are consistent with the reconstruction; however, indirect estimates from the 1982 census appear to be overestimated, whether one uses a North or a South model life table.

Figure 33a. Trends in under-five mortality, Zimbabwe, total

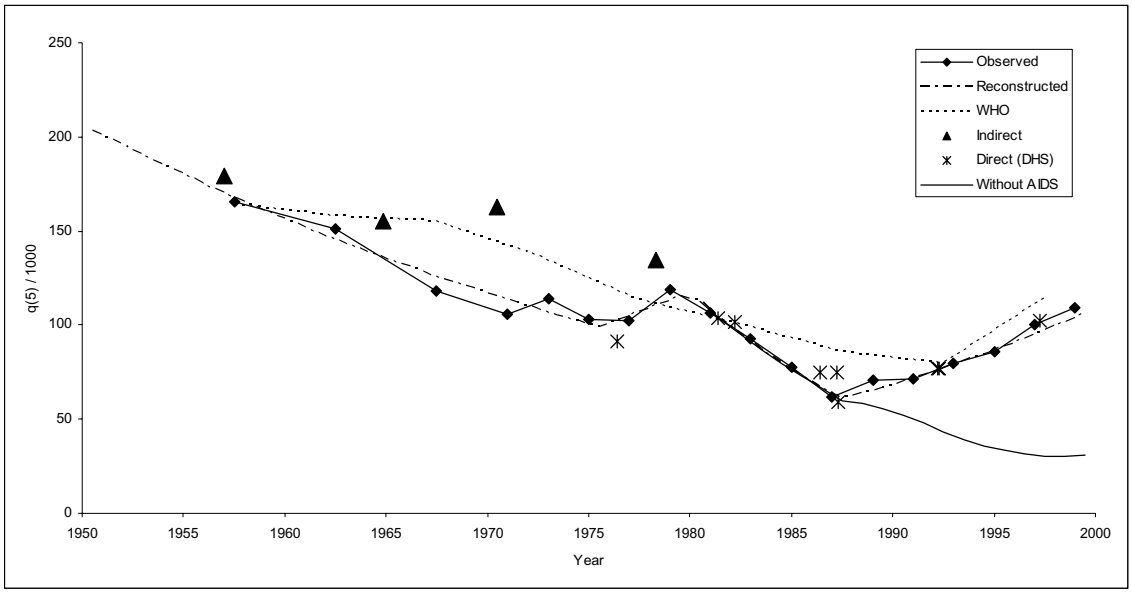
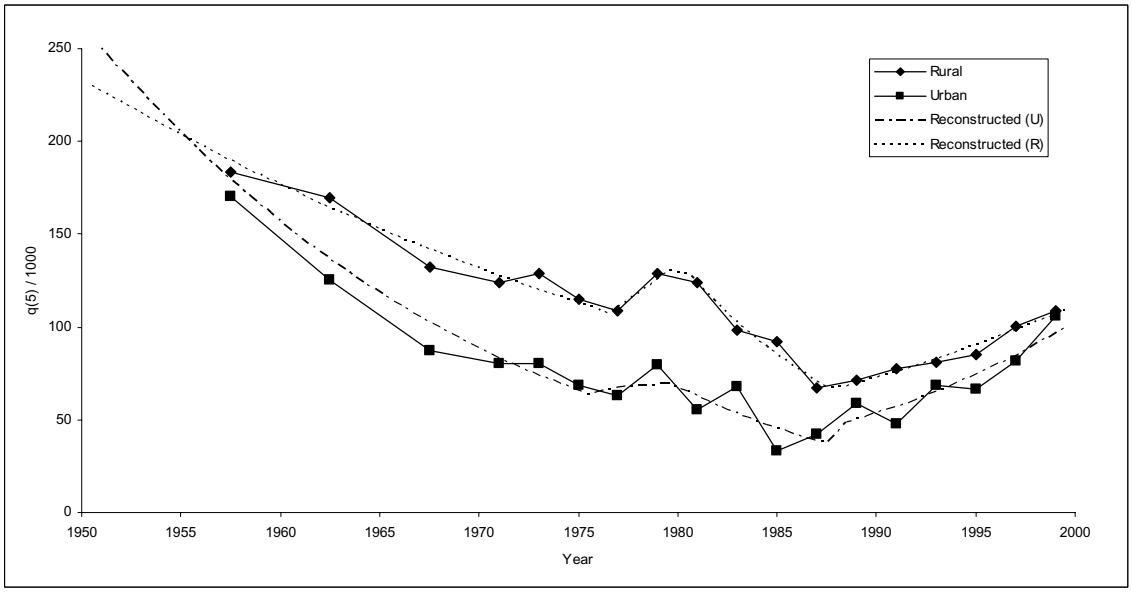


Figure 33b. Trends in under-five mortality, Zimbabwe, urban and rural



Appendix Table A-1: Estimations of Under-five Mortality from Trends Reconstruction, Sub-Saharan Africa

Under-five mortality q(5) per 1,000 live births

Year	Angola	Benin	Botswana	Burkina Faso	Burundi	Cameroon	Central-African Republic	Chad
1950	320	426	242	451	321	336	348	398
1951	315	418	232	444	312	329	339	392
1952	310	410	224	437	303	322	330	387
1953	305	402	215	430	294	316	322	381
1954	300	394	207	423	285	309	313	376
1955	295	386	198	416	276	302	305	370
1956	290	378	191	409	268	296	297	365
1957	286	371	183	402	260	289	289	359
1958	281	363	176	395	251	283	281	354
1959	276	356	168	388	244	276	273	348
1960	271	348	161	382	236	270	266	343
1961	267	341	155	375	228	264	258	338
1962	262	333	148	368	221	258	251	333
1963	258	326	142	361	214	252	244	327
1964	253	319	136	355	214	246	237	322
1965	249	312	130	348	216	240	230	317
1966	244	305	125	342	218	235	223	312
1967	240	298	119	335	219	229	216	307
1968	236	291	114	329	221	224	210	302
1969	231	284	109	323	223	218	203	297
1970	227	278	104	317	225	213	197	292
1971	223	271	100	310	226	208	191	287
1972	219	265	95	304	228	203	185	283
1973	215	258	91	298	230	198	179	278
1974	211	252	87	292	232	193	174	273
1975	207	246	83	286	233	188	174	268
1976	203	240	79	281	235	183	173	264
1977	199	234	76	275	237	179	172	259
1978	196	228	72	269	237	174	171	255
1979	181	222	69	264	223	170	170	250
1980	166	217	66	258	209	165	169	246
1981	152	215	63	253	196	161	169	242
1982	139	214	60	247	184	157	168	237
1983	127	212	57	242	172	153	167	233
1984	116	211	54	237	160	149	166	229
1985	106	209	52	232	150	145	165	225
1986	99	208	50	227	140	141	164	221
1987	108	206	47	222	130	137	164	217
1988	119	205	45	217		133	163	213
1989	130	199		212		130	162	209
1990	142	193		207		128	161	205
1991	156	188		202		131	160	201
1992	170	182		198		135	152	197
1993	185	177		193		138	144	194
1994	184	172		189		142	136	190
1995	162	167		185		145		186
1996	142	162		180		149		183
1997	124	157		176		153		179
1998		152		172		157		
1999		148		168				
2000		143						

Continued …

Under-five mortality q(5) per 1,000 live births (continued)

Year	Comoro Islands	Côte d'Ivoire	Ethiopia	Gabon	Ghana	Guinea	Kenya	Lesotho
1950		466	346	380	295	368	296	292
1951		454	342	368	282	366	287	279
1952		442	339	357	269	364	279	267
1953		430	335	345	256	362	270	255
1954		418	331	334	244	360	262	244
1955		406	328	323	232	358	254	233
1956		394	324	312	221	356	246	222
1957		383	321	301	210	354	238	212
1958		371	317	291	199	352	230	201
1959		360	314	281	189	351	222	192
1960	282	348	310	271	184	349	215	183
1961	275	337	307	261	182	347	208	176
1962	268	326	304	251	180	345	201	189
1963	261	316	300	242	178	343	194	202
1964	254	305	297	233	175	341	187	217
1965	248	295	293	224	173	339	181	212
1966	241	285	290	215	171	337	175	209
1967	235	275	287	207	169	335	169	206
1968	228	265	284	199	167	334	163	203
1969	222	256	280	191	165	332	157	200
1970	216	247	277	183	163	330	151	197
1971	210	238	274	176	161	328	146	193
1972	204	229	271	169	159	326	141	190
1973	199	220	268	162	157	324	135	187
1974	193	212	264	155	155	322	130	184
1975	188	204	261	149	153	321	126	182
1976	182	196	258	142	151	319	121	179
1977	177	188	255	136	149	317	117	176
1978	172	181	252	131	144	311	112	
1979	167	174	249	125	148	302	108	
1980	162	167	246	120	153	294	104	
1981	157	160	243	114	158	287	100	
1982	153	154	240	109	163	279	96	
1983	148	149	237	105	168	271	92	
1984	144	150	234	100	158	264	89	
1985	140	151	231	91	153	256	87	
1986	135	151	229	91	148	249	89	
1987	131	152	226	91	144	242	91	
1988	127	152	223	91	139	235	94	
1989	123	153	220	91	135	228	96	
1990	120	153	218	91	130	222	98	
1991	116	154	215	90	126	215	101	
1992	112	154	212	90	122	209	104	
1993	109	155	211	90	118	202	106	
1994	105	155	199	90	114	196	109	
1995	102	156	188	90	111	190	112	
1996	99	157	177	90	107	185	115	
1997		157	167	90	103	179	117	
1998		158	157	90	100	173	120	
1999		158	148	90	97	168	123	
2000			139	90				

Continued …

Under-five mortality q(5) per 1,000 live births (continued)

Year	Liberia	Madagascar	Malawi	Mali	Mozam-bique	Namibia	Niger	Nigeria
1950	451	285	550	542	400	234	527	325
1951	443	279	541	534	394	225	517	316
1952	435	274	531	527	387	217	508	306
1953	427	268	522	519	381	210	498	297
1954	420	263	512	512	374	202	488	288
1955	412	258	503	504	368	195	478	280
1956	404	252	494	497	362	188	468	271
1957	397	247	484	489	356	181	459	263
1958	389	242	475	482	350	174	449	254
1959	382	237	465	474	343	167	439	246
1960	374	232	456	466	337	161	430	238
1961	367	227	446	459	331	155	420	231
1962	360	222	437	451	325	149	410	223
1963	352	218	428	444	320	143	401	216
1964	345	213	419	436	314	137	391	207
1965	338	208	410	429	308	132	382	214
1966	331	204	400	422	302	127	373	222
1967	324	199	391	414	297	122	364	230
1968	317	195	382	407	291	117	355	239
1969	311	191	374	400	286	112	346	230
1970	304	186	365	392	280	108	337	222
1971	297	182	356	385	275	103	340	213
1972	291	178	347	378	269	99	340	205
1973	284	174	339	371	264	95	339	197
1974	278	170	330	364	259	99	339	190
1975	272	173	322	357	246	100	339	182
1976	265	175	314	350	233	101	338	175
1977	259	178	306	343	220	103	338	172
1978	253	181	298	336	208	104	337	173
1979	247	184	290	330	196	106	337	174
1980	241	187	282	323	185	111	337	175
1981	236	190	275	316	176	106	336	176
1982	230	193	263	310	185	102	336	177
1983	225	197	260	304	194	98	335	178
1984	219	200	258	297	203	94	335	179
1985	214	203	255	291	213	90	335	180
1986	208	206	252	285	223	86	334	181
1987		193	249	279	233	83	334	182
1988		187	247	273	243	79	333	183
1989		182	244	267	254	76	333	170
1990		176	241	261	266	72	333	163
1991		171	239	255	260	69	332	157
1992		166	231	249	239	66	332	150
1993		161	223	244	219	64	319	144
1994		156	215	238	201	61	289	139
1995		151	206	233	183	58	261	133
1996		146	199	227	167	52	234	128
1997		142	191	222	152	56	210	123
1998			184	217		61	187	118
1999			176	212		65		113
2000			169	207		70		Continued …

Under-five mortality q(5) per 1,000 live births (continued)

Year	Rwanda	Senegal	South Africa	Sudan	Tanzania	Togo	Uganda	Zambia
1950	346	394		199	350	334	330	451
1951	338	381		196	343	328	321	436
1952	329	368		194	335	322	311	421
1953	320	356		191	328	316	302	406
1954	312	343		188	321	311	293	391
1955	304	331		186	314	305	285	377
1956	296	319		183	307	299	276	363
1957	288	308		181	301	294	268	349
1958	280	296		178	294	288	259	335
1959	272	285		176	287	283	251	321
1960	264	293	278	173	281	278	243	308
1961	257	295	265	171	274	272	236	295
1962	250	296	253	169	268	267	228	282
1963	242	298	242	166	262	262	221	270
1964	235	300	230	164	256	257	213	258
1965	229	302	219	162	250	252	206	247
1966	227	304	208	159	244	247	199	235
1967	230	305	198	157	238	242	187	224
1968	233	307	188	155	232	237	176	214
1969	236	309	179	153	226	233	166	204
1970	239	304	170	150	221	228	156	194
1971	242	295	161	148	215	223	166	185
1972	245	285	153	146	210	219	170	176
1973	249	276	145	144	205	214	173	167
1974	252	267	137	148	200	210	177	158
1975	255	258	130	148	187	206	180	150
1976	258	249	123	148	177	201	184	154
1977	261	240	116	148	167	197	187	156
1978	243	232	110	148	158	193	191	158
1979	232	224	104	148	151	189	195	161
1980	221	216	98	148	156	185	198	163
1981	210	208	92	148	160	181	202	166
1982	200	201	87	149	165	177	206	168
1983	190	193	82	149	170	173	187	170
1984	181	186	78	149	175	170	183	173
1985	172	179	73	144	180	166	179	175
1986	163	173	69	133	165	162	175	178
1987	155	166	65	124	160	159	171	181
1988	147	160	61	115	156	155	167	183
1989	140	154	58	106	152	152	163	186
1990	132	148	54	98	148	148	160	188
1991	154	142	51		144	145	156	191
1992	181	137	48		140	142	153	194
1993	243	131	47		136	139	149	192
1994	308	126	51		132	136	146	187
1995	208	121	56		128	133	142	183
1996	187	116	62		125	130	139	178
1997	203	112	68			127	136	174
1998	232	107	74			124	132	170
1999	168	103					129	166
2000	142							162

Continued …

Under-five mortality q(5) per 1,000 live births (continued)

Year	Zimbabwe
1950	204
1951	198
1952	193
1953	188
1954	183
1955	178
1956	173
1957	168
1958	163
1959	159
1960	154
1961	150
1962	146
1963	141
1964	137
1965	133
1966	130
1967	126
1968	122
1969	119
1970	115
1971	112
1972	108
1973	105
1974	102
1975	99
1976	103
1977	107
1978	111
1979	116
1980	112
1981	103
1982	95
1983	87
1984	80
1985	73
1986	67
1987	61
1988	64
1989	67
1990	70
1991	74
1992	77
1993	81
1994	85
1995	89
1996	93
1997	97
1998	102
1999	107
2000	