The impact of AIDS on adult mortality: evidence from national and regional statistics

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Objective: To measure trends in adult mortality in countries with significant levels of HIV prevalence using data sources other than those that collect information on HIV status.

Data and methods: Data sources consisted of national population censuses and sample surveys, Demographic and Health Surveys (DHS), vital registration, and longitudinal surveillance systems. Estimates of adult mortality were derived from censuses using intercensal survival and questions on deaths of household members and orphanhood. From DHS adult mortality was measured from data on survival of siblings and orphanhood. Death registration should be tested for changes in the level of coverage before drawing conclusions on mortality trends. Demographic surveillance systems record trends and age patterns of mortality, but are not nationally representative.

Results: Census and survey data from Kenya, Malawi and Zimbabwe showed increasing adult mortality in the 1990s, reversing previous downward trends. DHS data for over 20 sub-Saharan countries showed that most had increasing mortality, which was steepest in eastern and southern Africa, with high HIV prevalences. Death registration in Zimbabwe and South Africa showed increasing adult mortality, as in Thailand and Trinidad, both countries with appreciable levels of HIV. Surveillance systems in Tanzania and South Africa showed radically different age patterns of mortality, with relatively high rates among younger adults compared with data from countries with lower HIV prevalences.

Conclusion: Adult mortality is increasing in countries with high HIV/AIDS prevalences, although the contribution of the epidemic to this increase is difficult to measure. More data and improved methods of analysis are needed before firm conclusions can be drawn.

AIDS 2004, **18** (suppl 2):S19–S26

Keywords: adult mortality, HIV/AIDS, sub-Saharan Africa

Introduction

The object of this review is to consider what effect AIDS is having on adult mortality in some of the countries most seriously affected by the epidemic, using public data sources, such as censuses and nationally representative surveys that do not offer a breakdown of the population by HIV status. Unlike the specialist surveys and cohort studies reviewed by Porter and Zaba in the previous section, these sources cannot provide us with direct evidence of mortality in HIV-infected individuals, but they can furnish indirect evidence of mortality impacts at a national level, as opposed to the small communities that are the focus of the earlier section. Is there evidence that adult mortality is increasing at a national level? If so, how much of the increase can be attributed to AIDS? The second question is more difficult to answer than the first: the data sources we will be examining rarely obtain information on the causes of death and when they do it is of doubtful reliability, particularly as regards AIDS-related deaths. However, the question needs to be

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DOI: 10.1097/01.aids.0000125980.64033.f0

asked, even if we can do little more than indicate the lines along which the answers may be obtained.

In countries lacking comprehensive systems of death registration, the measurement of adult mortality has been one of the more intractable problems facing demographers. Various methods have been developed, which are discussed below, but they are all based on assumptions and models that may or may not be appropriate for the population concerned. The advent of the AIDS epidemic has aggravated these difficulties. It has undermined many of the underlying assumptions and has given rise to age patterns of mortality that were never envisaged when the existing systems of model life tables were developed.

Data sources and methods

The answers we may be able to give to our two questions depend heavily on the nature and source of the statistics on adult mortality. Such sources may conveniently be divided into four categories: (i) population censuses and related sample surveys; (ii) Demographic and Health Surveys (DHS); (iii) death registration; and (iv) longitudinal surveillance systems. The DHS promulgated by ORC Macro have been placed in a separate category from the sample surveys in category (i) because their detailed and standardized instruments put them apart from other surveys.

Population censuses and sample surveys

In the absence of effective systems of vital registration, population censuses, supplemented by sample surveys, have constituted the principal means of tracking the demographic evolution of most of the countries of sub-Saharan Africa. Sometimes the information on fertility and mortality has been collected for a sample of the population, extra questions being asked in selected areas or households, or by means of a post-enumeration survey. We may also include in this category intercensal surveys, conducted at the midpoint (or thereabouts) of the intercensal decade, such as the 1997 survey of Zimbabwe.

A comprehensive review of the relevant results from the 2000 round of censuses is beyond the scope of this paper. In many cases the data are not yet available at the time of writing. This discussion will therefore be confined to an outline of the various ways in which census data may be used to estimate adult mortality, illustrated with results from the 1998 census of Malawi, the 1999 census of Kenya, and the 1997 Zimbabwe survey. We will examine three such ways: intercensal survival, recent deaths of household members, and orphanhood.

Intercensal survival

Adult mortality can be estimated by comparing the age–sex distribution of the population at successive censuses, a technique known as intercensal survival. Migration apart, the population of a specified age should be the survivors of those enumerated in the previous census held n years previously, when they were n years younger. Several different methods of doing this have been devised [1] (United Nations, 2004, in preparation). Such methods were used extensively to estimate mortality in the Indian subcontinent before the Second World War, but in Africa they are too often vitiated by varying degrees of coverage in the censuses and by migration.

Nevertheless, the analytical report on the 1998 census of Malawi shows the results of three different methods of intercensal survival between the 1987 and 1998 census, and they are compared with those obtained using the censuses of 1966, 1977 and 1987. In Table 1 these mortality rates have been condensed to give the probabilities of dying between the ages of 15 and 60 ($_{45}q_{15}$). They show a massive increase in mortality between 1977–1987 and 1987–1998, and the report attributes this increase to the HIV/AIDS epidemic. It is, however, pertinent to ask whether the figures should be accepted at their face value. The method is vulnerable to bias from migration, and Malawi has been subject to substantial migratory movements, both of refugees crossing and re-crossing between Mozambique and Malawi, and of labour migration, principally to South Africa. The analytical report does not state what steps, if any, were taken to minimize such bias.

Recent deaths of household members

Some censuses have included questions on the deaths of members of the household during the preceding 12 months. Such deaths are generally under-reported for a variety of reasons, prominent among which are the failure of the enumerators to ask the questions and the fact that households are liable to break up and disappear because of the death that has occurred. Various methods have been developed for testing the completeness of registered deaths [1,2] (United Nations, 2004 in preparation), most of them derived from the classic 'growth balance' method pioneered by Brass [3,4]. These methods can likewise be used with the deaths of household members reported in censuses and surveys;

Table 1. Malawi: probabilities of dying between ages 15 and 60 years ($_{45}q_{15}$) from intercensal survival.

	Males	Females
1966–1977	0.391	0.344
1977–1987	0.243	0.290
1987–1998	0.487	0.429

Source: Malawi census 1998, analytical report.

but they are all based on a variety of assumptions that need careful scrutiny in the special circumstances of the AIDS epidemic.

A question on deaths in the past 12 months was asked in the 1998 census of Malawi. In this case the unadjusted data give more plausible results than the application of the growth balance method. Age-specific mortality rates calculated from the reported figures gave values of $_{45}q_{15}$ of 0.516 for men and 0.447 for women. When graphed against the intercensal estimates described above and those derived by Timaeus and Jasseh [5] from the DHS sibling histories (see Fig. 1), they appear to lie rather below the trend line, but they are of a similar order or magnitude and lend weight to the belief that adult mortality in Malawi had been rising rapidly in the 1990s.

In Zimbabwe, questions on recent deaths were asked in the 1992 census and in the intercensal survey of 1997. The results have been analysed by Feeney [6], together with data on orphanhood, registered deaths and sibling histories from the DHS, discussed below. The unadjusted mortality rates gave values of $_{45}q_{15}$ for women of 0.301 in 1992 and 0.503 in 1997; corresponding figures for men were 0.411 in 1992 and 0.651 in 1997. These figures are generally commensurate with those obtained from the other sources and indicate a dramatic upsurge in adult mortality in the space of only 5 years.

Orphanhood

The subject of orphans and orphanhood has lately come to great prominence, as one of the dire consequences of the AIDS epidemic. However, data on age-specific patterns of orphanhood have for a long time constituted the most useful source of information on adult mortality to be obtained from the censuses. In Africa, the orphanhood questions 'Is your father alive?' and 'Is your mother alive?' were first asked in three demographic sample surveys in west Africa in the mid-1960s, followed by the 1969 censuses of Kenya and Uganda. At the same time, Brass [3,4] pioneered the analytical procedures for converting the proportions of individuals with parents alive into life table survival probabilities. Since then they have become quite popular, and many countries have repeatedly included these questions in their censuses. Kenya, for example, has now asked them in four successive censuses.

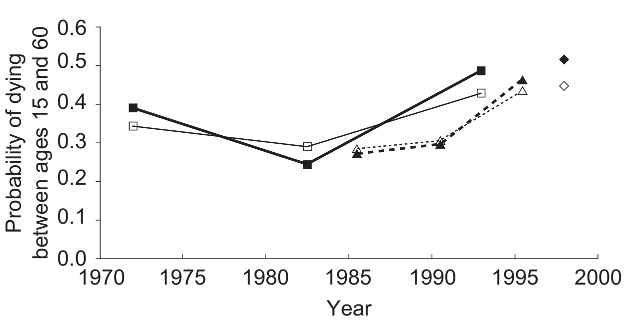

Fig. 1. Recent trends in male and female adult mortality in Malawi. Men: —■— Census survivors; —▲— Demographic and Health Survey siblings; ◆ Census deaths. Women: —□— Census survivors; —△— Demographic and Health Survey siblings; ◇ Census deaths.

The method is vulnerable to various potential errors and biases, which are discussed in detail by Blacker and Mukiza-Gapere [7]. In general, the orphanhood approach is more likely to produce underestimates, rather than overestimates, of mortality. This is particularly true of those estimates that are based on the reports for young children, which are susceptible to what has been termed 'the adoption effect', the substitution of foster parents, who are generally alive, for the real parents whose death has occasioned the adoption. In these circumstances the data for children under 10 years of age may become unusable.

In many ways, the most satisfactory method of using orphanhood data is the construction of 'hypothetical cohorts' from the changes in the proportions with parents alive for the same cohorts of respondents in two consecutive censuses or surveys, e.g. Kenyan women aged 20–24 in 1989 and 30–34 in 1999 [1]. This procedure gives a series of estimates over a wide age range for a common time location, which is reasonably close to the census or survey, and does not necessitate the use of model life tables (another potential source of bias). However, it requires the availability of two datasets, and if we want to examine trends, at least three data sets. In Kenya, as noted above, we were fortunate in having four datasets spaced at 10-year intervals, thus giving us three intercensal decades [8].

Orphanhood data do not provide life tables that start from birth, but rather conditional survival probabilities from an age that can be viewed as an approximation to the mean age of the parents at the birth of the child: for women this is usually taken as age 25 years, for men as age 35 years. For the sake of simplicity, the Kenyan results have been condensed into simple summary indices, representing the person-years lived ($_nL_x$) and lost between the ages of 35 and 75 years for men and between 25 and 75 years for women. If nobody died between these ages, the number of years lived per person would be 40 for men and 50 for women. The 'years lost' therefore represent the extent to which the person-years lived fall short of 40 and 50, respectively. They are shown in Table 2. The years lost show an appreciable drop between 1969–1979 and 1979–1989, followed by an increase of the order of

Table 2. Kenya: orphanhood estimates of person-years lived and lost.

	Hypothetical intercensal cohorts		
	1969–1979	1979–1989	1989–1999
Men 35–75 years			
Years lived	31.0	32.5	29.6
Years lost	9.0	7.5	10.4
Women 25–75 years			
Years lived	43.4	44.8	42.8
Years lost	6.6	5.2	7.2

Source: Blacker *et al.* [8].

50% for both sexes between 1979–1989 and 1989–1999.

How much of this increase in mortality can be attributed to AIDS? The census, of course, does not provide any information on the cause of death, but estimates of AIDS-related mortality may be derived from the data on HIV prevalence built up since the start of the epidemic, using the software package Spectrum developed by the Futures Group International [9]. In the case of Kenya, these calculations suggested that although AIDS accounted for most of the increase in adult mortality, there had also been an increase in mortality from other causes. The validity of this conclusion depends heavily on the official estimates of HIV prevalence, and as these have been revised retrospectively more than once, our faith in their permanence must remain fragile.

In Zimbabwe, the orphanhood questions were also included in the 1982, 1992 and (presumably) 2002 censuses, and in the intercensal survey conducted in 1997. The results from the 2002 census are not available at the time of writing, but Feeney [6] calculated mortality rates from hypothetical cohorts for 1982–1992 and for 1992–1997. His estimates of ${}_{35}q_{30}$ (the probability of someone aged 30 years of age dying before reaching the age of 65 years) for women were 0.191 for 1982–1992 and 0.511 for 1992–1997; those for men were 0.259 for 1982–1992 and 0.549 for 1992–1997. These figures therefore suggest that the mortality of both sexes had more than doubled in less than a decade.

Demographic and health surveys

Unfortunately, DHS have never included the orphanhood questions addressed to adults in their surveys, although they have recently asked them of children under 15 years, not in order to estimate adult mortality, but to estimate the increasing numbers of orphaned children arising from the AIDS epidemic. Before the epidemic, DHS seem to have eschewed, not just the orphanhood questions, but the whole subject of adult mortality, despite its importance as a component in any country's demography.

With effect from 1992, however, DHS have offered participating countries an optional module of questions on sibling survival from the results of which age-specific adult mortality rates can be calculated directly. Each eligible female respondent aged 15–49 years is asked about her brothers and sisters: their dates of birth, whether they are alive or dead, and if dead, their dates of death. Between 1992 and 2000, 23 sub-Saharan African countries included these questions in their surveys, and of these three, Malawi, Uganda and Zimbabwe, asked them in two successive surveys. These 23 countries comprise nearly three-quarters of the population of sub-Saharan Africa, although there are some conspicuous and regrettable omissions, notably Botswana, Lesotho and Swaziland, Angola, Burundi, Democratic Republic of Congo and Ghana.

In the published DHS reports, the mortality rates from the sibling histories for the last, say, 7–10 years before the survey have been amalgamated, so we only have one mortality rate for each age group, and thus no indication of trends. However, Timaeus and Jasseh [5] have calculated the rates for single calendar years, and as numbers are small and random fluctuations large, they have modelled them using Poisson regression. Their results have therefore enabled us to discern trends over time, and at the same time have provided a comprehensive and succinct summary for much of sub-Saharan Africa. The only countries for which the results appear to be basically implausible are Ethiopia and Nigeria. In the former, the data show a dramatic decrease in mortality, for which there is no rational explanation; in the latter, the rates appear to be increasing, but from an initial level well below that of any other country in sub-Saharan Africa. The figures for Ethiopia and Nigeria have therefore been omitted from Table 3, which shows their estimates of ${}_{45}q_{15}$ for the remaining 21 countries.

Only five countries showed roughly constant or falling mortality: Benin, Mali, Niger, Rwanda and Senegal. With the possible exception of Rwanda (where mortality in 1995 may still have been elevated as a result of the genocide and where HIV peaked early), all these are thought to be countries with a relatively low prevalence of HIV. The remaining 16 all showed increasing mortality, although the rate of increase varied considerably. Zambia and Zimbabwe, where HIV prevalence is known to be exceptionally high, are conspicuous at the upper end of the range with their mortality more than doubling in 10 years. However, in Uganda, where HIV prevalence is known to have declined, the mortality rates for women show a small downturn between 1995 and 2000. Some countries where the epidemic arrived relatively late, notably

Table 3. Estimates of the probabilities of dying between 15 and 60 years ($_{45}q_{15}$) from Demographic and Health Surveys sibling histories: mortality per 1000.

	Women				Men			
Country	1985	1990	1995	2000	1985	1990	1995	2000
Benin	201	187	173	–	250	232	216	–
Burkina Faso	–	225	237	251	–	271	305	346
Cameroon	–	147	226	–	–	179	276	–
C.A.R.	308	367	469	–	348	418	558	–
Chad	–	206	219	–	–	189	207	–
Cote d'Ivoire	204	252	340	–	257	319	452	–
Guinea	–	189	190	325	–	197	188	357
Kenya	–	175	262	–	–	185	292	–
Malawi	275	306	435	–	272	306	464	–
Mali	244	230	219	–	259	244	236	–
Mozambique	–	147	181	–	–	181	224	–
Namibia	172	183	–	–	318	336	–	–
Niger	251	198	–	–	252	199	–	–
Rwanda	–	–	458	363	–	–	610	533
Senegal	165	163	–	–	186	184	–	–
South Africa	–	135	147	–	–	280	302	–
Tanzania	127	184	266	–	166	236	360	–
Togo	–	162	204	–	–	187	238	–
Uganda	274	339	416	415	310	395	511	545
Zambia	149	339	547	–	159	372	623	–
Zimbabwe	94	187	378	566	113	232	486	726

Source: Timaeus and Jasseh [5].

South Africa and Namibia, are clearly in need of a more up-to-date survey.

The general plausibility of the results is thus highly encouraging, although their validity is difficult to assess, and possible biases need to be examined. For example, the generally rising trends could be partly attributable to progressive recall lapse the further back in the past the siblings died [10]. A crucial test of consistency is to compare the trends revealed by successive surveys for the same countries with overlapping reference periods. Timaeus and Jasseh [5] have done this with the three countries that, at the time of writing, have asked the questions in two successive surveys, Malawi, Uganda and Zimbabwe. They concluded that 'adult mortality is underestimated by about 25 per cent in the survey reports for 6–8 years before the second survey, compared with 0–2 years before the first survey'. Therefore, some of the apparent increase in mortality may be spurious, but discrepancies of this magnitude are small compared with the massive increases in mortality between 1985 and 1995/2000 recorded for the three countries concerned. Nevertheless, it is as well to bear in mind that the DHS sibling histories are liable to underestimate adult mortality, a conclusion also reached by others working in this field [11].

Timaeus and Jasseh [5] also made mortality estimates from the DHS data on orphanhood for the 5–9 and 10–14 years age groups. When compared with the sibling-based estimates, they concluded that, with three conspicuous exceptions, 'these two sets of results are broadly consistent'. The three exceptions are Mozambique and Rwanda, where the orphanhood estimates may have been affected by the long histories of civil unrest in those countries, and Nigeria, which would seem to be an added reason for distrusting the sibling-based estimates from that country.

In 10 countries the orphanhood questions have been asked in two or more successive surveys, thus providing indices of change. They show roughly constant or falling mortality in Ghana, Madagascar, Niger and Uganda, and rising mortality in Cameroon, Kenya, Rwanda, Tanzania, Zambia and Zimbabwe. These results are entirely commensurate with the current figures of HIV prevalence. Estimates for the end of 2001 published by UNAIDS [12] showed that in three of the four countries with constant or falling mortality, 5% or less of adults aged 15–49 years were HIV positive, and for the fourth country, Niger, there were no data. In the six countries with increasing mortality, the prevalence ranged from 7.8% in Tanzania to 33.7% in Zimbabwe.

Registered deaths

In most of the countries seriously affected by AIDS, notably those in sub-Saharan Africa, the registration of deaths is either non-existent or so incomplete as to be unusable for demographic analysis. Therefore, of the three papers submitted to the Durban conference, which use registered deaths as their principal data source, two are concerned with countries outside the African region, namely Trinidad [13] and Thailand [14]; the third paper is on South Africa [15], which is one of the few countries south of the Sahara where the civil registration system is such as to provide a potential source of data on mortality trends. Perhaps the only other country in this category is Zimbabwe, and we will include in this review the results of the sophisticated analysis by Feeney [6] comparing these data with those from other sources.

The death registration data in all these four countries show evidence of increasing mortality, particularly among younger adults. Therefore, in Thailand the registered mortality rates of men aged 15–49 years increased from 2.8 per thousand in 1987 to 5.4 in 1996, whereas that for women rose from 1.4 to 1.7 during the same period. In South Africa, the total number of registered deaths increased by 42% between 1998 and 2001; the number of reported deaths of women aged 25–29 years almost trebled during those 3 years. For Zimbabwe, the adjusted estimates of Feeney [6] of ${}_{45}q_{15}$ for men increased from 295 per thousand in 1986 to 553 in 1995, and from 210 to 417 for women.

Could these increases have been caused, at least partly, by improvements in the coverage of the registration systems? The authors of three of the four studies address this question, and perhaps somewhat ironically all three agree that there had been such improvements. There are two approaches to this problem. One is to compare the registered mortality rates with those derived from other sources; the other is to use the internal evidence from the age distribution of the registered deaths and that of the living population, using techniques based on the 'growth balance' method [16], such as the variable growth rate methods of Bennet and Horiuchi [17,18].

Im-Em [14] in a study of Thailand adopted the first approach. The author used data from the Survey of Population Change (a periodic dual-record survey) to measure the coverage of the death registration, and concluded that it had improved from 75.7% in 1985–1986 to 95.8% in 1995–1996. Despite corrections for these and other shortcomings in the data, the Thai registration data continued to show evidence of increasing mortality attributable to AIDS. Bradshaw and Dorrington [15], using the Bennet–Horiuchi method, showed that in South Africa the registration of deaths improved from 54% in 1990 to 89% in 1999–2000. Nevertheless, the adjusted mortality rates show massive increases in the late 1990s: the rate for women aged 25–29 years was 3.5 times higher in 1999–2000 than in 1985; those for men aged 30–34 and 35–39 years almost doubled, but the increases were from a higher base level in 1985. With the Zimbabwe data, Feeney [6] used a modified form of the Brass growth balance method; the author concluded that the coverage of the death registration of adults aged 15–65 years improved from 57% in 1986 to 85% in 1995 for men and from 40 to 59% for women. The author does not show the original unadjusted mortality rates, and the massive increases in adult mortality cited above became apparent after making the necessary adjustments.

The assessment of the contribution of AIDS to mortality increases calculated from registered deaths poses further difficulties. A first step is doubtless to look at the cause-of-death data. However, there are generally grounds for believing that AIDS is likely to be underreported as a cause of death, partly because of the stigma attached to it and partly because AIDS is not the immediate cause of death: it opens the way to an opportunistic infection from which the patient cannot recover. It is widely believed that both in Thailand and in Trinidad the numbers of registered deaths officially attributed to AIDS are much too low. Boisson *et al.* [13] and Im-Em [14] explored the alternative assumption that all the increase in mortality is caused by AIDS, extrapolating the trends observed before the epidemic began and assuming that any subsequent divergence between the extrapolated and observed figures can be attributed to AIDS. What sort of a curve should be fitted to the pre-AIDS trends to make the extrapolation? Im-Em [14] evidently used a simple straight line; Boisson *et al.* [13] fitted a logistic curve. But what guarantee have we that mortality, in the absence of AIDS, would follow the extrapolated curve? None, really, and the data of Boisson *et al.* [13] illustrated this. Their figures showed that mortality rates for both sexes at ages 45–64 years, have fallen below the extrapolated curves; for those aged over 65 years the observed rates are higher than the extrapolated curves, but at these ages the discrepancy can scarcely be caused by AIDS. However, the increasing mortality shown for ages between 15 and 45 years can more plausibly be attributed to the epidemic.

The assumption that the differences between the observed and extrapolated trends is entirely attributable to AIDS may well be justifiable in the cases of Thailand and Trinidad. However, it would be more difficult to vindicate in some sub-Saharan African countries, where other factors may have contributed to the increase in mortality: deteriorating health services and living standards (aggravated by the AIDS epidemic), and the resurgence of other diseases, most notably malaria and tuberculosis. In this respect, an examination of the age patterns of mortality can be of great value. AIDS has, of course, a very characteristic age pattern: high in infancy and early childhood as a result of vertical transmission, dropping virtually to zero around the age of 10 years, then rising rapidly in early adult ages, peaking earlier for women than men, then dwindling virtually to zero in old age [19]. Bradshaw and Dorrington [15] compared the changes in the age patterns of mortality shown by the South African registration data with those predicted by their models, and the agreement is good.

Demographic surveillance systems

The prospective recording of births and deaths in selected study areas in Africa was initiated more than 50 years ago with the well-known MRC study in Keneba in The Gambia in 1950, followed by the Pare-Taveta Malaria Study on the borders of Kenya and Tanzania in 1954 [20]. Since then, such studies have proliferated in several countries of Africa, and in 1998 many of them became affiliated to the International Network for the Continuous Demographic Evaluation of Populations and Their Health, or INDEPTH, which has among its objectives the exchange of information and improvements in the methodologies of data collection and analysis. In 2002, INDEPTH comprised 17 surveillance sites in sub-Saharan Africa, together with two in Asia.

Surveillance systems of this type do not normally consist of probability samples, so their demographic data cannot be regarded as representative of the country, or even of the region where they are sited. In so far as they are sometimes the subject of trials of health interventions, they may become more unrepresentative over time. Some studies of this type collect data in an intervention area and contrast this with a comparison area in which the intervention has not been applied. These comparison areas are sometimes used as indicators of what may be happening in the country on a wider scale. Therefore, if the death records in our surveillance sites show increasing mortality that can be attributed to AIDS on the basis of specialized cause-of-death allocation, we should not be surprised if data on a national scale, even if fragmentary, indicated similar trends.

Clark *et al*. [21] examined the mortality data from surveillance sites in Tanzania (Dar es Salaam, Morogoro and Hai) and in South Africa (Agincourt), where verbal autopsies have been used to calculate separate mortality rates for AIDS/tuberculosis and for other causes. In Dar es Salaam during the period 1994–2001, mortality as a result of AIDS/tuberculosis was approximately equal to that from all other causes combined for both sexes aged 15–50 years. In Agincourt it increased the level of mortality by approximately a third; other areas in Tanzania showed intermediate contributions. However, in all the Tanzanian sites, the increases in mortality caused by AIDS/tuberculosis were more than compensated by declines in death rates from other causes, so that all-cause mortality fell in the later 1990s. This finding contrasts with that of Timaeus and Jasseh [5], whose analysis of the DHS data described above definitely showed increasing mortality for Tanzania. It also contrasts with the situation in Kenya, where overall all-cause mortality, both of children and adults, undoubtedly rose in the 1990s. In Agincourt, on the other hand, all-cause mortality in this age group (15–50 years) more or less doubled during the decade.

Surveillance data can be of great value for the construction of more realistic model life tables for Africa and for other countries where AIDS has an appreciable effect on the age patterns of mortality. Given the fragmentary and uncertain nature of African mortality data, model life tables are essential tools for the demographer. However, it is well known that when the existing models, such as those of Coale and Demeny [22] and the United Nations [23], were formulated, no African data were incorporated in their construction. Even the so-called ‘African Standard’ devised by Brass [24] was not based on any African data; at least not over the age of 10 years. However, now the INDEPTH team have identified from their surveillance data seven different patterns of mortality, of which two comprise a heavy element of AIDS (INDEPTH, 2002). They propose a new relational model life table standard that incorporates raised mortality in early adult ages. An alternative approach to constructing life tables incorporating the effect of HIV would be to add a sex-specific ‘AIDS component’ between the ages of 20 and 60 years, whose level and precise age location could be varied according to HIV prevalence, epidemic maturity and mean age at infection.

Discussion

It will have been apparent from the foregoing that whereas information on adult mortality may be gleaned from a variety of sources, they are all subject to potential errors and biases that cannot be ignored. An extensive body of analytical techniques has been developed for identifying and correcting these errors, but they are all based on assumptions and models that may or may not be appropriate for the population under study. The AIDS epidemic has aggravated these biases, undermined many of the assumptions underlying the correction procedures, and produced age patterns of mortality that were never envisaged when the currently available systems of model life tables were constructed. There is an urgent need for research in these areas. The pioneer work of P. Ward and B. Zaba (2004, in preparation) on child mortality, Timaeus and Nunn [25] on orphanhood, and the INDEPTH model life tables constitute valuable first steps in these directions, but they need to be taken further. Therefore, both the Ward–Zaba and the Timaeus–Nunn adjustments are based on the assumption that the epidemic has stabilized, and the latter are for women only. We need procedures that can be applied when the epidemic is still increasing, and we need them for paternal as well as maternal orphanhood.

There are of course discrepancies between the mortality indices derived from the different sources, but the general picture that is emerging is clear. The sibling histories compiled in the DHS, which at present constitute our most ubiquitous source, have shown increasing adult mortality in three-quarters of the countries in sub-Saharan Africa where the questions have been asked; and these increases have been steepest in countries where HIV prevalence is known to be highest. They have also been confirmed by data obtained from censuses, other sample surveys, and civil registration in countries such as Kenya, Malawi, Zimbabwe and South Africa.

The next few years should see a steady accretion in the available data. More results of the 2000 round of censuses should be analysed and published, including those from Zambia (2000), Tanzania (2001), Namibia (2001), South Africa (2001), Uganda (2002) and Zimbabwe (2002). At the same time, more countries will be conducting further rounds of DHS with sibling histories, thus facilitating a critical assessment of the Timaeus–Jasseh procedure for deriving mortality trends from these data. More of these DHS will also be collecting blood samples, thus putting the estimates of HIV prevalence on much firmer bases, so that estimates of AIDS mortality derived from population projection models will also be more secure. It would also hugely improve our knowledge of adult mortality in general if DHS could extend the orphanhood questions, asking not only children under 15 years, but the whole population about the survival of parents.

When discussing the impact of AIDS on mortality we have been concerned primarily with the mortality of HIV-positive individuals. However, the epidemic has affected mortality in ways other than through the virus. It has been largely instrumental in the resurgence of tuberculosis, and perhaps other diseases too, which may spread to the HIV-negative population [26]. Furthermore, targeting as it does the bread-winning age groups, it has brought with it widespread poverty, misery, malnutrition and disaster, all of which may be reflected in the increasing mortality rates.

References

1. United Nations. Manual X. Indirect techniques for demographic estimation, (ST/ESA/SER.A/81). New York; 1983.
2. Preston SH. Use of direct and indirect techniques for estimating the completeness of death registration systems. United Nations Data Bases for Mortality Measurement. New York; 1984.
3. Brass W. **Demographic data analysis in developing countries, 1946–96.** Population Studies, 1996; **50**:451–468.
4. Brass W, Hill K. **Estimating mortality from orphanhood**. In: International Population Conference. Liège, 1973; **3**:111–123.
5. Timaeus IM, Jasseh M. **Adult mortality in sub-Saharan Africa: evidence from the Demographic and Health Surveys**. *Paper presented to Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, March 2003.
6. Feeney G. **The impact of HIV/AIDS on adult mortality in Zimbabwe.** Popul Dev Rev 2001; **27**:771–780.
7. Blacker J, Mukiza-Gapere J. **The indirect measurement of adult mortality in Africa: results and prospects**. In: African Population Conference. Dakar, 1988; **2**:3.2.2 23–38.
8. Blacker J, Kizito P, Obonyo B. **Projecting Kenya's mortality: using Spectrum to project the AIDS and non-AIDS components**. *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, 2003.
9. Futures Group International Spectrum. Programme and manuals can be downloaded at www.FuturesGroup.com 2003.
10. Bicego G. **Estimating adult mortality rates in the context of the AIDS epidemic in sub-Saharan Africa: analysis of DHS sibling histories**. Health Trans Rev 1997; **7 (Suppl. 2)**:7–22.
11. Stanton C, Abderrahim N, Hill K. DHS maternal mortality indicators: an assessment of data quality and implications for data use. Calverton: Macro International; 1997.
12. UNAIDS. Report on the global HIV/AIDS epidemic. Geneva; 2002.
13. Boisson E, Legall G. **A comparison of adult excess mortality from the Trinidad and Tobago vital registration system with reported AIDS cases**. *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, 2003.
14. Im-Em W. **Use of vital registration data to estimate the contribution of HIV to mortality trends.** *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, 2003.
15. Bradshaw D, Dorrington R. **The use of South African vital registration data to estimate the contribution of HIV to changing trends in mortality.** *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, 2003.
16. Brass W. Methods for estimating fertility and mortality from limited and defective data. Chapel Hill: University of North Carolina; 1975.
17. Bennet NG, Horiuchi S. **Estimating the completeness of death registration in a closed population**. Popul Index 1981; **47**: 207–221.
18. Bennet NG, Horiuchi S. **Mortality estimation from registered deaths in less developed countries.** Demography 1984; **21**: 217–233.
19. Urassa M, Boerma JT, Isingo R, Ngalula J, Ng'weshemi J, Mwaluko G, Zaba B. **The impact of HIV/AIDS on mortality and household mobility in rural Tanzania.** AIDS 2001; **15**:2017–2023.
20. Feachem RG, Jamison DT, editors. Disease and mortality in Sub-Saharan Africa. Oxford University Press for the World Bank, Washington DC; 1991.
21. Clark S, Setel P, Kahn K, Whiting D, Collinson M, Hemed Y, et al. **The role of AIDS/TB in mortality patterns in east and southern Africa: evidence from four demographic surveillance sites**. *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, 2003.
22. Coale AJ, Demeny P. Regional model life tables and stable populations. Princeton, NJ: Princeton; 1966.
23. United Nations. Model life tables for developing countries, ST/ESA/SER.A/77. New York; 1982.
24. Brass W, Coale AJ. **Methods of analysis and estimation.** In: Brass W, Coale AJ, Demeny P, Heisel DF, Lorimer F, Romaniuk A, van de Walle E, editors. The demography of tropical Africa. Princeton University Press, Princeton NJ; 1968.
25. Timaeus I, Nunn AJ. **Measurement of adult mortality in populations affected by AIDS: an assessment of the orphanhood method**. Health Trans Rev 1997; **7 (Suppl. 2)**:23–43.
26. Sonnenberg P, Glynn JR, Fielding K, Murray J, Godfrey-Fausset P, Shearer S. **HIV and pulmonary tuberculosis: the impact goes beyond those infected with HIV**. *Paper presented to the Conference on Empirical Evidence for the Demographic and Socioeconomic Impact of AIDS*. Durban, March 2003.