Adult Mortality in Sub-Saharan Africa: Evidence from Demographic and Health Surveys*

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ABSTRACT

The paper investigates levels, trends and age patterns of adult mortality in 23 sub-Saharan Africa countries using the sibling histories and orphanhood data collected by their Demographic and Health Surveys. In general, adult mortality rose sharply after HIV became prevalent, but the size and speed of this rise in mortality varies greatly between countries. Excess mortality is concentrated among women aged 25-39 and men aged 30-44. These data suggest that the increase in the number of deaths of men has exceeded somewhat that for women. It is time for a systematic attempt to reconcile the demographic and epidemiological evidence concerning AIDS in Africa.

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INTRODUCTION

The information available on levels and trends in adult mortality in sub-Saharan Africa and on age patterns of mortality in the region remains limited. Most of the estimates for sub-Saharan African countries in the series of mortality and life expectancy statistics produced by various international agencies are made without reference to empirical data on adults (Lopez et al. 2001; Stanecki 2004; United Nations 2002). For example, in most of Africa, the United Nations Population Division simply assumes that mortality at all ages conforms to a Princeton North model life table fitted to an estimate of under-five mortality (United Nations 2002). Similarly, the estimates of AIDS deaths in high prevalence countries produced by UNAIDS are based on epidemiological models fitted to HIV seroprevalence data collected in antenatal clinics (UNAIDS Reference Group on Estimates Modelling and Projections 2002). While these models are based on careful review of the data coming out of a range of research studies, at present no attempt is made by UNAIDS to use empirical data on mortality in national populations to estimate AIDS deaths in particular countries.

One reason why adult mortality estimates for Africa are often imputed from models is that routine data on adult mortality in sub-Saharan Africa remain rare. Civil registration of deaths has only yielded useful data in studies of particular cities (e.g. Garenne et al. 1996) and for two national populations: South Africa and Zimbabwe (Dorrington et al. 2001; Feeney 2001). Even in these countries, the data are incomplete. In addition, reporting of causes of death is poor as many of the deaths that are registered are not certified medically. Moreover, deaths from HIV/AIDS are particularly likely to be reported as from other diseases.

Demographic surveillance systems can provide extremely useful information on mortality in adulthood as well as childhood (INDEPTH Network 2002). Unfortunately, they are limited in number and, except in Tanzania, cover only small populations. Censuses lack these limitations. They can be used to estimate adult mortality when the census schedule includes either direct questions about deaths in households during the recent past or questions about whether household members are orphans. Moreover, even if data are obtained on deaths in the household that are incomplete or subject to reference period errors, they can often be corrected using Brass's growth balance method and related techniques (Brass 1975; Hill 1987; Preston et al.

1980). One or both sets of questions about adult mortality were asked in a number of 1980 and 1990 round censuses in Africa. Although some of the data generated were of very poor quality, analysis of those that were not yielded estimates of adult mortality in the 1980s for about a dozen sub-Saharan African countries (Timæus 1993, 1999a). Unfortunately though, the United Nations Statistics Division failed to strongly promote questions on adult mortality for inclusion in the 2000 round of censuses and few additional African countries responded to the growing epidemic of HIV/AIDS by asking them. Even where the questions were asked, often the results have yet to be published. Therefore, census data are currently of limited value for documenting recent trends in adult mortality in Africa.

The Demographic and Health Survey (DHS) programme of surveys is the only source of direct nationally-representative data on recent adult mortality that covers a large number of African countries. Unfortunately, not only have DHS surveys not been conducted everywhere, but only some of the surveys have collected the sibling histories that represent the main source of information on adult mortality. Moreover, the data obtained are subject to recall and other reporting errors.

In earlier research, 11 DHS surveys in sub-Saharan Africa that had collected sibling histories prior to 1997 were used to estimate recent adult mortality directly (Timæus 1998, 1999a). This research showed that, while adult mortality was falling or stagnant in West Africa and in Namibia in the 1980s, it had begun to rise sharply in East Africa. Moreover, four of the six East African countries were characterised by unusually high mortality of young adults relative to older adults. Unfortunately, DHS surveys cover rather small samples for the study of adult mortality. Thus, the East African surveys lacked by a large margin the statistical power required to yield meaningful estimates of how the age pattern of mortality in adulthood was evolving in each country as the overall death rate rose.

The aim of the analysis reported here is to investigate levels, trends and age patterns of adult mortality in sub-Saharan Africa using the sibling history data now available from 26 DHS surveys. The first objective of the study is to assess the reliability of these sibling history data by examining their internal plausibility and consistency, by comparing successive surveys, and by comparing mortality estimates made from these histories with those based on orphanhood. Second, the paper is concerned to quantify the extent to which adult mortality rose during the 1990s in African countries experiencing generalized epidemics of HIV/AIDS. Third, it seeks to describe the age pattern of mortality increase for each sex that is resulting from AIDS. In order to achieve these objectives, the paper adopts a novel approach to modelling the sibling histories that identifies the typical age pattern of mortality change in the 23 countries considered.

DATA AND METHODS

This paper is based largely on the analysis of the sibling histories collected as part of the maternal mortality module in 26 Demographic and Health Surveys (DHS) conducted in 23 mainland sub-Saharan African countries between 1992 and 2000 (see Table 1). This module collects data from women aged 15-49 years about each of their brothers and sisters in turn. The information obtained includes the date of birth of each sibling, their sex, and, if they have died, their date of death. Thus, the histories include all the information needed to calculate age-specific death rates directly for the period preceding collection of the data (Rutenberg and Sullivan 1991).

The respondents' surviving siblings will be, on average, about the same age as the respondents themselves. A sibling born, for example, 30 years before the survey may have died at any time during that period. Thus, the histories provide information on deaths and exposure before age 15 as well as after that age. Moreover, because some respondents have older brothers and sisters who were born more than 50 years earlier, the sibling histories also yield some information on mortality at ages 50 or more.

Because these data are collected retrospectively they are liable to errors of recall. It seems likely that most respondents will have fairly clear memories of the timing of recent deaths but their knowledge of the ages (and therefore ages at death) of their brothers and sisters is likely to be more approximate. When exact dates of birth and death were not reported, they were imputed before the data were made publicly available taking into account reported ages, ages at death, and intervals since the death. Failure to report siblings that the respondent has lost touch with will only bias the data if this is related to their probability of dying. However, respondents may well fail to report siblings, especially older siblings, who died very young. Thus, we make no attempt to use these data to estimate mortality at ages 0-4 years.

As few African countries have reliable mortality estimates from other sources against which the sibling history data can be evaluated, the severity of these recall and other reporting errors remains unclear. An initial investigation of DHS sibling history data suggested that respondents can report the ages and ages at death of their siblings but that reporting of when siblings died is both less complete and subject to rounding errors (Stanton, Abderrahim and Hill 1997). It found that sibling histories tend to yield lower adult mortality estimates for the period seven to 13 years ago than for zero to six years before the data were collected. In most countries outside Africa this is implausible and suggests that such data are of little value for study of medium-term trends in mortality. Moreover, on the basis of comparison of the more recent estimates with other estimates 'of good quality', the report suggests that even the recent sibling history estimates may underestimate adult mortality, especially for women. For Africa, however, Stanton *et al.* (1997) only had independent results for one country, Senegal, and these results may overestimate mortality in that country: they were made using 1988 Census data (Pison *et al.* 1995) that we believe require adjustment if they are not to overestimate mortality.

After examining the unsmoothed data for the 15 years before each survey, it was decided to base this study on the reports for the period zero to eight completed years before each survey was conducted. In many African countries, the numbers of deaths being reported begins to drop off at about this point and the mortality rates for more than a decade ago are manifestly too low. Moreover, in most of the surveys, heavy heaping exists of reported dates of deaths on ten years before the data were collected. This suggests that the reports on nine to eleven years ago should be either included in the analysis or excluded from it, as is done here, as a block. In Rwanda, exceptionally, only data on the six years before the survey are used. So many of the Tutsi population died in the 1994 genocide that reports about siblings made by surviving members of the population will not reflect mortality during either the genocide or the period that preceded it. After discarding information on the 0.7 per cent of siblings reported in the 26 surveys whose survival status or gender is unknown, the data set covers more than 7½ million sibling-years of exposure at ages 5-69 during the nine-year windows before each survey and includes almost 41 thousand deaths of siblings (see Table 1).

Despite the impressive sounding totals of deaths and exposure in the 26 survey data set, too few deaths occur in each five-year age group and three to five year interval of time to estimate the schedule of age-specific mortality rates in each country sufficiently precisely to be of use. Thus, instead of such straightforward calculations, we adopt an analytic strategy intended to extract as much information as possible from the histories:

- The deaths by single years of age and time are modelled using Poisson regression. Statistically insignificant interaction terms, for example sex differences in the age pattern and trend in mortality before the onset of the HIV/AIDS epidemic, are dropped from the fitted models.
- It is assumed that mortality at all ages in each country follows a single log-linear trend until four years after the date at which UNAIDS estimate that adult HIV prevalence reached 1 per cent. The rise in AIDS deaths lags behind the spread of HIV infection and an interval of about this duration has been observed between the development of a generalized HIV/AIDS epidemic and the onset of mortality increase in populations with detailed annual series of deaths data (Notkola, Timæus and Siiskonen 2004 in press; Timæus et al. 2001).

- The explanatory variables include a external single-year standard set of mortality rates that is based on the Princeton South Level 16 model life tables (Coale, Demeny and Vaughan 1983) but has been transformed slightly to make it more representative of sub-Saharan African experience (Timæus 1999b). This standard serves to smooth the observed rates, excluding any additional mortality after the onset of the HIV/AIDS epidemic. The coefficient of the standard rates, which determines the age pattern of mortality relative to the standard, is allowed to vary between countries but not to change over time. Thus, the non-AIDS component of the estimates of mortality can be considered as coming from fitted two-parameter relational model life tables in which the level of mortality changes at a different rate in each country but the age pattern of mortality varies only between countries and not over time within each country.
- It is assumed that any new trend in mortality after the time of the onset of the HIV/AIDS epidemic only affects adults aged 20-69. The model allows mortality to rise at a different rate for each sex in each of the five-year age groups from 20 to 59 and at 60-69. However, it is assumed that this age pattern of mortality increase is the same in all of the countries. This will not be exactly true. Nevertheless, patterns of sexual behaviour and the epidemiology of AIDS share common features across sub-Saharan Africa, suggesting that age patterns of HIV infection and AIDS mortality are likely to be similar across the continent (Heuveline 2003). Thus, as DHS samples are too small to measure country-specific changes in the age pattern of mortality, our approach estimates instead the typical age pattern of mortality increase in African populations hit by AIDS.
- The speed with which mortality rises due to AIDS can vary between countries. It is estimated as a country-specific multiplier applied to the common age pattern of mortality increase. In most countries, it is assumed that mortality is rising exponentially. However, in a few countries the data suggest that the rate of mortality increase had begun to decelerate by the end of the period under observation. In these countries, the logged death rates were modelled as a quadratic function of the duration of the epidemic.
- In sum, we model the underlying trend in adult mortality in each country both before and after the onset of its HIV/AIDS epidemic, the age pattern of adult mortality from causes other than AIDS in each country, and the overall age pattern of mortality increase by age group and sex in the 23 countries combined (but without reweighting to reflect the relative size of each country's population). A close parallel exists between this approach and that developed independently by Heuveline (2003) in order to model the typical age pattern of HIV incidence by sex in Eastern Africa.

Thus, the death rate at age x of sex g in country i at time t, $\ln(\mu(x,g,i,t))$, is modelled as:

$$\begin{aligned}\ln(\mu(x,g,i,t)) &= \beta_0 + \beta_1(g,i) + \beta_2(i)t + \beta_3(i)\ln(\mu_s(x,g)) \\ &+ \{(\beta_4(g,i) + \beta_5(x^*,g))(t-T_i) + \beta_6(g,i)(t-T_i)^2 I(i \in S)\} I(t > T_i) I(x \geq 20)\end{aligned} \quad (1)$$

where x^* is the five-year age group that contains x, the $\mu_s(x,g)$ are standard mortality rates, T_i is 4 years after the date when HIV seroprevalence in the adult population of country i is thought to have risen to 1 per cent, and $I(i \in S)$, $I(t > T_i)$ and $I(x \geq 20)$ are indicator variables which are one if the condition is met and zero otherwise. The subset, S, of countries in which evidence exists that the exponential rise in mortality after the onset of the HIV/AIDS epidemic moderates with time comprises Malawi, Uganda, Zambia, and Zimbabwe. The regression model simplifies to the first line of Equation (1) in the following instances: those countries where the sibling histories were collected too early to reflect any rise in mortality due to AIDS (Benin, Namibia, Niger, and Senegal); prior to four years after the onset of the epidemic in all other countries; and for ages 5-19 in all countries and years.

Mortality is also estimated from data on the orphanhood of children aged 5-14 years. This information is collected on the household schedule of most DHS surveys conducted in sub-Saharan Africa. The data required concern the survival of the fathers and mothers of children aged 5-9 and 10-14 years. They are available from 36 surveys in 25 countries, including all but one of those that collected sibling histories.

The maternal orphanhood data are adjusted for biases arising from the reduced fertility of HIV positive women and the mortality of vertically-infected children. On the basis of approximate expressions for these biases developed by Timæus and Nunn (1997), the proportion of children aged 10-14 with living mothers is reduced by 47.5 per cent of the estimated prevalence of HIV infection in the adult female population at the time of their birth. For children aged 5-9 the adjustment is halved. The proportions of children with living fathers are reduced by 60 per cent of these amounts based on estimates of the concordance of infection in partnerships compiled by Grassly and Timæus (forthcoming).

Having made these adjustments for under-representation of dead adults in the reports of surviving children, most of the orphanhood data were analysed using standard methods (Timæus 1992). However, those on mothers from surveys in populations with a high prevalence of HIV infection at the time of the children's birth (details available from the first author) were analysed using revised regression coefficients that reflect the impact of AIDS on age patterns of mortality among adult women (Timæus and Nunn 1997). Both methods yield two estimates of adult women's mortality, shown in Table 2, the probabilities of dying between ages 25 and 35 (${}_{10}q_{25}$) and ages 25 and 40 (${}_{15}q_{25}$). However, the data on paternal orphanhood in two age groups of children yield just one estimate of men's mortality, the probability of dying between ages 35 and 50 (${}_{15}q_{35}$). As we still know rather little about the impact of AIDS deaths on age patterns of mortality in Africa, no basis exists for extrapolating from these measures of mortality to mortality over any other age range. Thus, we compare them with estimates for the same ages calculated using the regression model fitted to rates calculated directly from the sibling histories.

RESULTS

Three countries have collected two sets of sibling histories – Malawi, Uganda, and Zimbabwe, though in Malawi the estimates overlap only for just over a year. By adding a term to Equation (1) for the survey round in which the data were collected, one can assess whether each pair of sets of data is mutually consistent. This reveals that in each of the three countries the more distant reports in the later survey represent significantly lighter mortality than the most recent reports from the earlier survey. No evidence exists that the size of the discrepancy differs between the reports on brothers and those on sisters. The coefficients suggest that adult mortality in Malawi and Zimbabwe is underestimated by about 16 per cent in the survey reports for six to eight years before the second survey, compared with zero to two years before the first survey. In Uganda the relative level of omissions in the more distant reports from the second survey is 32 per cent. These findings are worrying. If the completeness of reporting of dead siblings decays by about 20 per cent as the interval since the death increases by six years, even the most recent reports may be somewhat incomplete, which would imply that the absolute level of omissions is even higher.

One can also assess the sibling histories by comparing the fitted mortality estimates from the regression model for 4½ years before the survey with the estimates calculated from data on orphanhood (see Figure 1 – the points joined by lines are those for the four countries that collected orphanhood data in two surveys that refer to the period covered by the sibling histories). These two sets of results are broadly consistent. Nearly as many sibling history estimates exceed the orphanhood estimates as are lower than them. Moreover, sibling history estimates for sisters and orphanhood estimates for mothers appear as consistent with each other as the corresponding two sets of estimates made from reports about brothers and fathers. However, the sibling history data do indicate much lower adult mortality than all the orphanhood estimates in three countries, Mozambique, Nigeria, and Rwanda. In Mozambique and Rwanda this is because the orphanhood estimates are based on the lifetime experience of cohorts of children. They are not precisely time-referenced and reflect earlier mortality from violence in these countries. In Nigeria, however, it is known that the sibling histories were poorly administered in the field (National Population Commission 2000). The very low mortality indicated by them for this country is implausible and should probably be discounted.

Focusing on the sibling histories, Table 3 presents estimates of the probability of dying between ages 15 and 60 (${}_{45}q_{15}$) calculated from the age-specific death rates in the fitted regression model. Wide variations in levels in adult mortality between countries existed in Africa in the late 1980s even at the outset of the HIV/AIDS epidemic. In the mid-1980s, ${}_{45}q_{15}$ in the Central African Republic was about three times higher than in Zimbabwe. Mortality in Nigeria seems implausibly low. Adult mortality may have been rising in a number of coastal West African countries even before the onset of AIDS deaths. In contrast, rapid declines in adult mortality were occurring in most of the Sahel.

In 16 of the 19 countries in which the sibling histories cover the relevant period, they record a significant discontinuity in the trend in adult mortality about four years after the country developed a generalized HIV/AIDS epidemic (Figure 2). The exceptions are Ethiopia, Nigeria and Rwanda. Although these three series of estimates seem somewhat implausible, the evidence is not clear cut and their inclusion has little effect on the estimated age pattern of mortality increase and so they are retained in the analysis. Only limited rises in mortality occur in the first 7.5 years of an HIV/AIDS epidemic. The fastest rises in mortality have occurred in South Africa, Zambia, Zimbabwe, Uganda, and Cameroon. Adult mortality has risen relatively slowly in Kenya, Tanzania and has hardly changed at all in Burkina Faso.

As a result of these divergent trends, levels of adult mortality in Africa became far more diverse by the mid-1990s than they had been a decade earlier. By 1995, the probability of dying between ages 15 and 60 had risen to about 55 per cent for women and 64 for men in both Uganda and Zambia (Table 3). By 2000 it also reached this level in Malawi and had risen to almost 59 per cent for women and to 70 per cent for men in Zimbabwe.

The excess mortality in countries with a generalised HIV/AIDS epidemic is concentrated at young ages, in particular among women aged 25-39 and men aged 30-44 (Figure 3a). While the relative rise in women's mortality exceeds that in men's mortality, in absolute terms men's mortality rises by more (Figure 3b). Multiplying out by an appropriate age structure, these rates suggest that about 20 per cent more men than women die of AIDS early in the epidemic, dropping to 10 per cent excess of male AIDS deaths as the epidemic matures. As AIDS mortality rises, a very unusual age pattern of mortality develops with little gradient in mortality with age over the entire age range 30-64 (Figure 3c). Women's mortality may actually decline with increasing age for middle-aged women.

DISCUSSION

It is difficult to assess the accuracy of the sibling history estimates of adult mortality in Africa. It probably varies markedly between countries. The evidence from three countries that have collected sibling histories twice is that the quality of the data decays as the recall interval extends. On the other hand, no consistent differences exist between the estimates calculated from the sibling histories and those based on orphanhood. Moreover, there is no tendency for estimates from these two sources to diverge at higher mortality, which might be expected if either approach was biased severely in the presence of severe AIDS mortality (Figure 1). It is also reassuring that, although nothing in the regression model imposes this, the mortality increases for men that are calculated from data on respondents' brothers correlate highly with the mortality increases for women that are calculated from data on their sisters (Table 3).

Zimbabwe is almost the only country in which the sibling history estimates for the 1990s can be compared with statistics from a civil registration system and from other censuses and surveys (Feeney 2001). (This should also be possible in South Africa once the full results of the 2001 Census are published). As it happens, Zimbabwe is also the country that registers the largest rise in mortality. Comparison of them with Feeney's estimates suggests that the sibling history estimates of ${}_{45}q_{15}$ for 1997 are abut 10 per cent too low and those for 1990 about 30 per cent low. This is broadly consistent with what was suggested by the comparison of the results from two surveys.

On the basis of this rather fragmentary evidence, it appears likely that the sibling histories usually estimate recent mortality fairly accurately but that they exaggerate the rate at which adult death rates are rising, perhaps doing so by around 4 per cent per year. Adjusting for a bias of this size this would reduce the doubling in women's death rates at ages 20-24 and 60-69 shown in Figure 3a to an increase of about a third, which seems more plausible, and also reduce the rise in the death rates for other age groups and for men to about two thirds of the values shown.

Even if one takes this pessimistic view of the quality of the DHS sibling histories, they continue to confirm that a sharp increase in adult mortality has occurred in Africa since HIV became prevalent. For example, the adjusted estimates for Zimbabwe still indicate that ${}_{45}q_{15}$ has more than tripled. The explosive rise in mortality occurs only in the second decade of the epidemic. The greatest increases in mortality occur among women aged 25-44 and among men aged 30-49. Our results also emphasize that large variations exist between countries in the timing and speed of the rise in mortality. The AIDS epidemic is not following the same path throughout Africa and, despite their limitations, estimates derived from the DHS sibling histories are capable of differentiating between countries with more severe and less severe AIDS mortality and between rapidly and slowly developing epidemics.

In principle, levels of HIV infection in antenatal clinics are a better source of information for monitoring the HIV epidemic than these data on mortality. In some African countries, however, they continue to be based on small and unrepresentative samples of clinics. Mortality estimates potentially represent an important supplementary source of estimates to which projection models could be calibrated. It is reassuring, therefore, that the size and speed of the rise in mortality in different countries documented by the DHS sibling history data are broadly in line with predictions from epidemiological data and models (e.g. United Nations Joint Programme on HIV/AIDS 2002). For example, they indicate that adult mortality was already rising sharply in Uganda and Zambia in the late 1980s. By the late 1990s, however, the upward trend in mortality had levelled off in Uganda and was also doing so (at a much higher level) in Zambia. Mortality began to rise much later in Zimbabwe and South Africa but these countries have experienced a particularly rapid increase in adult mortality. In these instances, the mortality estimates are in line with existing projections.

Some of the other findings reported here are unexpected. Certain of these unexpected results undoubtedly reflect reporting errors in the sibling histories. For example, we have already suggested that Nigeria is unlikely to have markedly lower adult mortality than other Western African countries. However, other surprising features of African mortality patterns suggested by these data merit further investigation. For example, on the basis of UNAIDS' estimates of HIV prevalence in the adult population one might have expected mortality to have risen more in Kenya by 1998 than in Tanzania by 1996 (United Nations Joint Programme on HIV/AIDS 2002). According to these data, it had not. The reported rises in mortality in Burkina Faso and in Togo are also surprisingly small. On the other hand, the large rise reported in adult mortality in Guinea in the second half of the 1990s is probably the only firm evidence that exists to support the idea that an HIV/AIDS epidemic is now raging in the country.

For many, the most implausible feature of these results may be that they suggest that 10 to 20 per cent more men than women have died of AIDS in Africa. It is possible that female respondents fail to report more dead sisters than dead brothers when they are asked about their siblings. None of the checks we have made on the estimates revealed any evidence of this but they may not be sensitive enough to reveal a relatively small bias which is still sufficient to produce an unexpected sex differential in numbers of AIDS deaths. On the other hand, even if a larger rise really has occurred in men's mortality, this may not contradict the observation that, in cross-section, more women than men in Africa are infected with HIV (UNAIDS Reference

Group on Estimates Modelling and Projections 2002). Instead, as Gregson and Garnett (2000) show, an excess of deaths of men over those of women could well be a temporary feature of a growing epidemic and/or reflect the shorter survival times of those infected at older ages, who tend to be men. Undoubtedly though, the sex differential in mortality increase suggested by the sibling histories is a potentially important feature of the epidemic that could be important for our understanding of the population dynamics of HIV/AIDS in Africa.

Most of Africa lacks routine vital statistics. The reason for persisting with the DHS sibling histories despite the limitations that arise from the relatively small sample of deaths on which data are collected and from incomplete reporting is that these histories are the only data on adult mortality that exist for many African countries. There is no doubt that the best basis for forecasting current and future AIDS mortality in Africa will remain the data on current HIV infections generated by unlinked testing of blood samples collected in antenatal clinics and from surveys of representative population samples. Nevertheless, it is important to recognise both that estimates of the prevalence of HIV infection in Africa remain subject to large errors and that using these data to predict AIDS deaths involves numerous, sometimes insecurely founded, assumptions (UNAIDS Reference Group on Estimates Modelling and Projections 2002). It is time for a systematic attempt to reconcile the demographic and epidemiological evidence concerning AIDS in Africa in order to improve our knowledge of the key parameters that drive the epidemic. In particular, antenatal clinic data provide direct information on HIV prevalence in the female population only. Making more use of the demographic data may offer the best hope of developing a fuller understanding of the scale and dynamics of the epidemic among men. Thus, estimates and projections of the HIV/AIDS epidemic should be calibrated against data on mortality and orphanhood.

In addition to making full use of existing data, obtaining more and better data on adult mortality in Africa is crucially important to improving knowledge and understanding of the AIDS epidemic and to the design of programmes intended to mitigate its impact. National statistics institutes, technical advisers, donors and researchers all need to assign more priority to the collection of adult mortality data for Africa. Demographic surveillance, census questions about both recent deaths in the household and orphanhood, and the collection of sibling histories by the DHS and similar surveys can all contribute to this task.

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TABLE 1. DEATHS AND EXPOSURE TO RISK OF SIBLINGS AGED 5+ IN THE 9 YEARS BEFORE EACH SURVEY

Country	Date of fieldwork	Deaths of siblings by age at death: 5-14 years	15-29 years	30-49 years	50+ years	Deaths of siblings by interval before survey: 0-2 years	3-5 years	6-8 years	Total sibling deaths	Total sibling-years of exposure
Benin	1996	165	199	219	46	215	216	198	629	190,354
Burkina Faso	1998-99	270	392	341	45	378	405	265	1048	219,320
Cameroon	1998	201	310	276	59	401	257	187	845	214,821
Central African Rep.	1994-95	210	566	541	42	561	491	306	1359	208,384
Chad	1996-97	281	434	338	12	398	324	344	1066	260,086
Côte d'Ivoire	1994	246	495	510	60	547	474	290	1311	304,451
Ethiopia	2000	859	1467	1427	202	1178	1447	1330	3955	548,478
Guinea	1999	192	270	270	43	305	249	221	775	207,606
Kenya	1998	205	546	603	73	651	498	278	1427	370,168
Malawi	1992	247	354	371	46	438	352	228	1018	174,930
	2000	518	1510	2014	185	1974	1335	918	4228	490,953
Mali	1995-96	294	439	441	51	401	460	363	1224	330,782
Mozambique	1997	426	547	281	33	435	497	355	1287	278,964
Namibia	1992	154	373	346	47	350	329	240	919	223,687
Niger	1992	414	441	311	41	333	449	426	1208	226,532
Nigeria	1999	232	265	196	34	336	215	176	727	302,079
Rwanda[a]	2000	421	1158	1331	96	1521	1484	–	3005	259,146
Senegal	1992-93	224	248	231	33	243	296	197	736	224,135
South Africa	1998	82	476	735	171	691	440	333	1464	379,609
Tanzania	1996	255	489	573	56	632	449	292	1373	331,214
Togo	1998	260	421	425	95	517	378	306	1201	326,861
Uganda	1995	332	919	856	57	1062	635	466	2164	294,351
	2000-01	281	919	1088	77	1029	725	612	2366	306,520
Zambia	1996	283	1155	1324	102	1448	923	492	2863	352,087
Zimbabwe	1994	100	352	446	82	557	288	135	980	276,354
	1999	97	567	1003	88	963	555	236	1755	259,345
Totals		7249	15,312	16,497	1875	17,565	14,171	9194	40,933	7,561,217

[a] For Rwanda, only data on the 6 years before the survey are included in this table and the analysis

TABLE 2. PROBABILITY OF DYING IN EARLY ADULTHOOD BY SEX, DEMOGRAPHIC AND HEALTH SURVEY ORPHANHOOD DATA

Country/Survey	Approximate Reference Date[a]	Women's mortality at ages 25-35	Women's mortality at ages 25-40	Men's mortality at ages 35-50
Benin	1992.0	0.035	0.047	0.070
Burkina Faso	1988.6	0.047	0.063	0.099
Cameroon	1986.9	0.028	0.050	0.081
	1993.7	0.044	0.061	0.112
Central African R.	1990.4	0.067	0.077	0.139
Chad	1992.7	0.045	0.050	0.102
Cote d'Ivoire	1990.2	0.035	0.043	0.079
Ethiopia	1995.7	0.094	0.088	0.132
Ghana	1989.3	0.036	0.051	0.087
	1994.5	0.041	0.042	0.077
Guinea	1994.9	0.045	0.053	0.099
Kenya	1988.8	0.026	0.030	0.096
	1993.7	0.050	0.053	0.134
Madagascar	1988.1	0.061	0.091	0.110
	1993.3	0.045	0.075	0.092
Malawi	1988.2	0.064	0.074	0.101
Mali	1991.6	0.030	0.042	0.065
Mozambique	1992.8	0.066	0.118	0.117
Namibia	1988.2	0.024	0.042	0.091
Niger	1987.8	0.037	0.074	0.070
	1993.8	0.035	0.049	0.064
Nigeria	1994.8	0.050	0.055	0.076
Rwanda	1988.1	0.041	0.055	0.125
	1996.1	0.182	0.204	0.446
Senegal	1988.6	0.023	0.045	0.076
South Africa	1993.7	0.028	0.043	0.135
Tanzania	1987.4	0.036	0.051	0.093
	1992.2	0.079	0.067	0.113
	1995.2	0.105	0.080	0.124
Togo	1993.8	0.042	0.050	0.101
Uganda	1990.8	0.146	0.110	0.198
	1996.4	0.133	0.189	0.189
Zambia	1987.6	0.048	0.054	0.097
	1992.2	0.127	0.099	0.175
Zimbabwe	1990.2	0.081	0.054	0.127
	1995.2	0.157	0.117	0.237

[a] The estimate of women’s mortality at ages 25-35 refers to 1 year after this date and that of women’s mortality at ages 25-40 to 15 months before it.

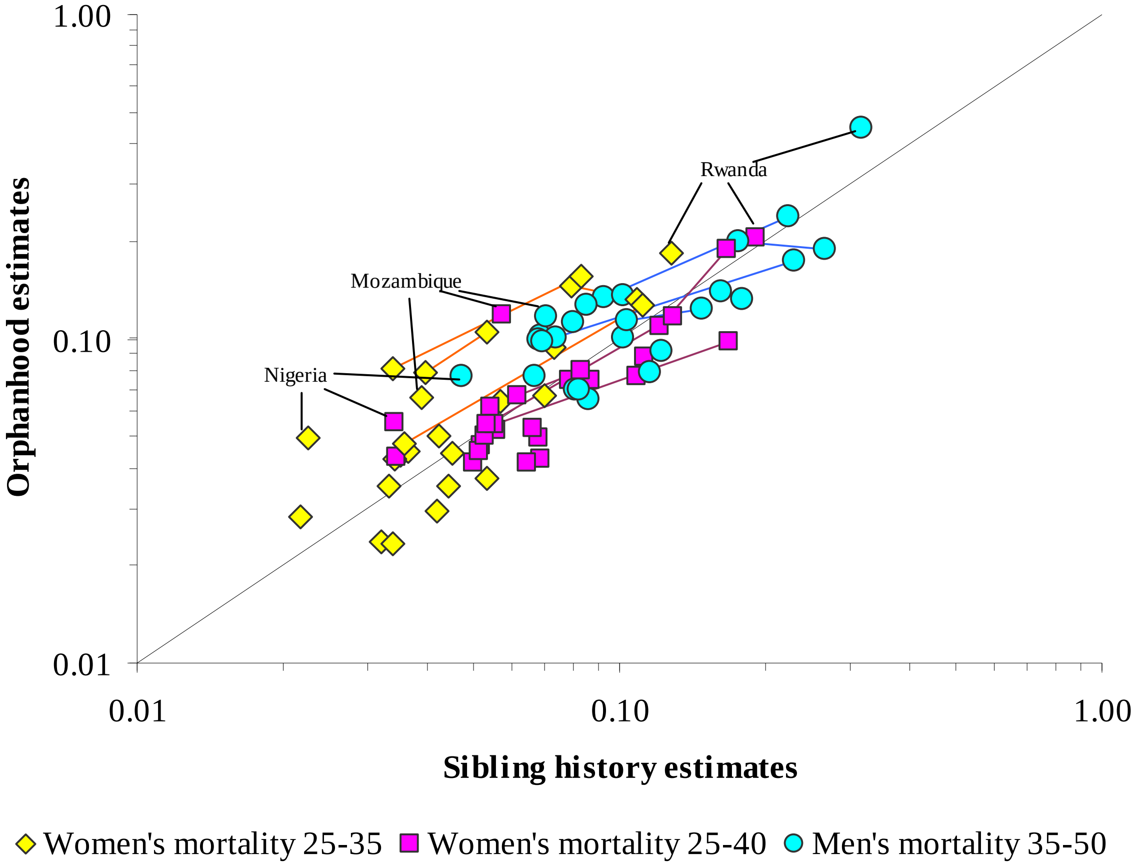
TABLE 3. PROBABILITY OF DYING BETWEEN EXACT AGES 15 AND 60 (${}_{45}q_{15}$) BY SEX, DEMOGRAPHIC AND HEALTH SURVEY SIBLING HISTORIES

	Women				Men			
Country	1985	1990	1995	2000	1985	1990	1995	2000
Benin	0.201	0.187	0.173	--	0.250	0.232	0.216	--
Burkina Faso	--	0.225	0.237	0.251	--	0.271	0.305	0.346
Cameroon	--	0.147	0.226	--	--	0.179	0.276	--
Central African R.	0.308	0.367	0.469	--	0.348	0.418	0.558	--
Chad	--	0.206	0.219	--	--	0.189	0.207	--
Côte d'Ivoire	0.204	0.252	0.340	--	0.257	0.319	0.452	--
Ethiopia	--	0.433	0.342	0.266	--	0.503	0.423	0.359
Guinea	--	0.189	0.180	0.325	--	0.197	0.188	0.357
Kenya	--	0.175	0.262	--	--	0.185	0.292	--
Malawi	0.275	0.306	0.435	--	0.272	0.306	0.464	--
Mali	0.244	0.230	0.219	--	0.259	0.244	0.236	--
Mozambique	--	0.147	0.181	--	--	0.181	0.224	--
Namibia	0.172	0.183	--	--	0.318	0.336	--	--
Niger	0.251	0.198	--	--	0.252	0.199	--	--
Nigeria	--	0.076	0.114	0.179	--	0.093	0.140	0.233
Rwanda	--	--	0.458	0.363	--	--	0.610	0.533
Senegal	0.165	0.163	--	--	0.186	0.184	--	--
South Africa	--	0.135	0.147	--		0.280	0.302	--
Tanzania	0.127	0.184	0.266	--	0.166	0.236	0.360	--
Togo	--	0.162	0.204	--		0.187	0.238	--
Uganda	0.274	0.339	0.416	0.415	0.310	0.395	0.511	0.545
Zambia	0.149	0.339	0.547	--	0.159	0.372	0.623	--
Zimbabwe	0.094	0.187	0.378	0.566	0.113	0.232	0.486	0.726

FIGURE 1. COMPARISON OF SIBLING HISTORY AND ORPHANHOOD ESTIMATES OF EARLY ADULT MORTALITY, DEMOGRAPHIC AND HEALTH SURVEYS

FIGURE 2. TRENDS IN THE PROBABILITY OF DYING BETWEEN AGES 15 AND 60 ($_{45}q_{15}$) ACCORDING TO YEARS INTO THE HIV/AIDS EPIDEMIC, WOMEN, DEMOGRAPHIC AND HEALTH SURVEY SIBLING HISTORIES

FIGURE 3. RISE IN MORTALITY BY AGE AND SEX ACCORDING TO YEARS SINCE THE ONSET OF A GENERALIZED HIV/AIDS EPIDEMIC IN A TYPICAL AFRICAN POPULATION, DEMOGRAPHIC AND HEALTH SURVEY SIBLING HISTORIES


1.00
0.10
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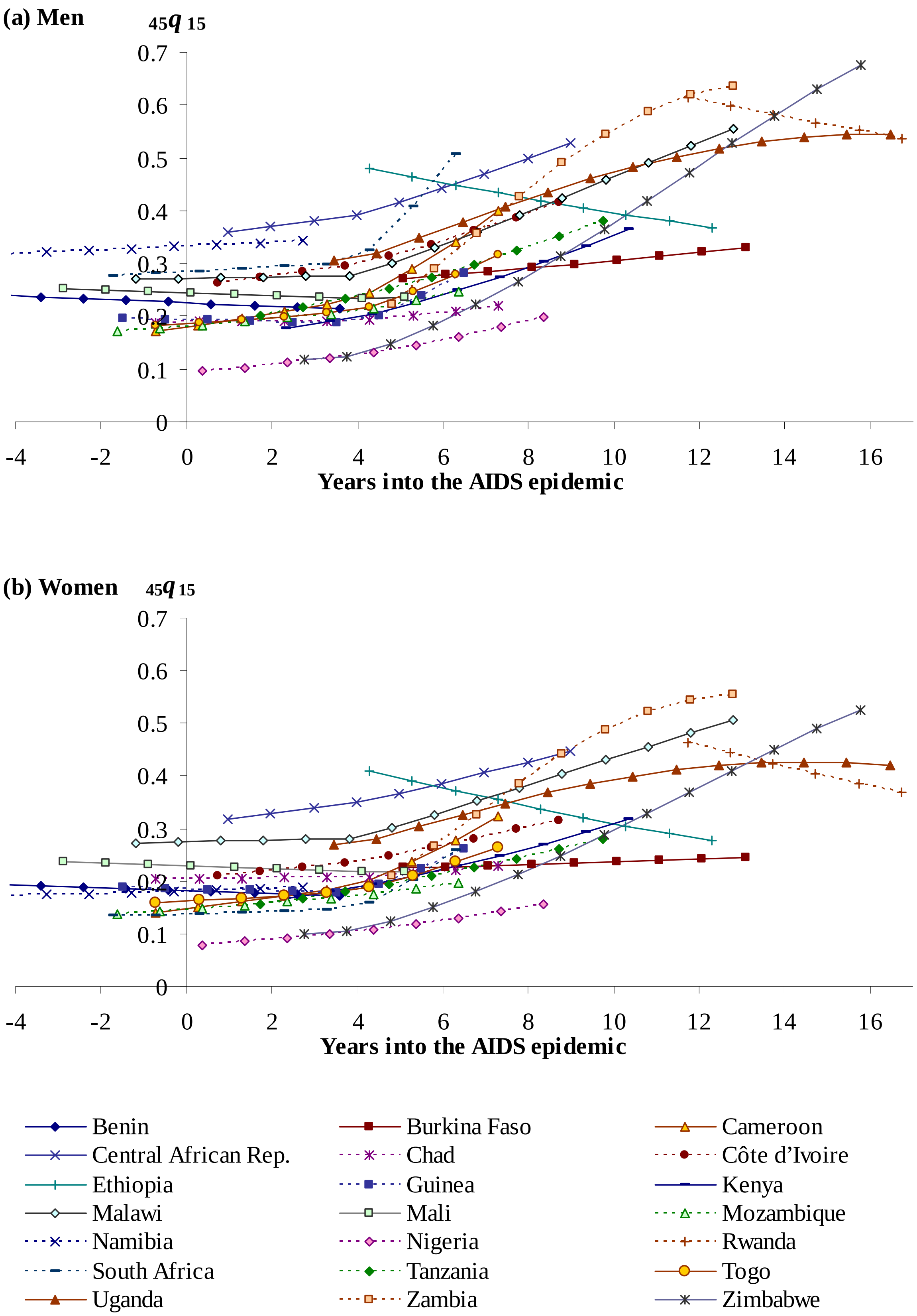
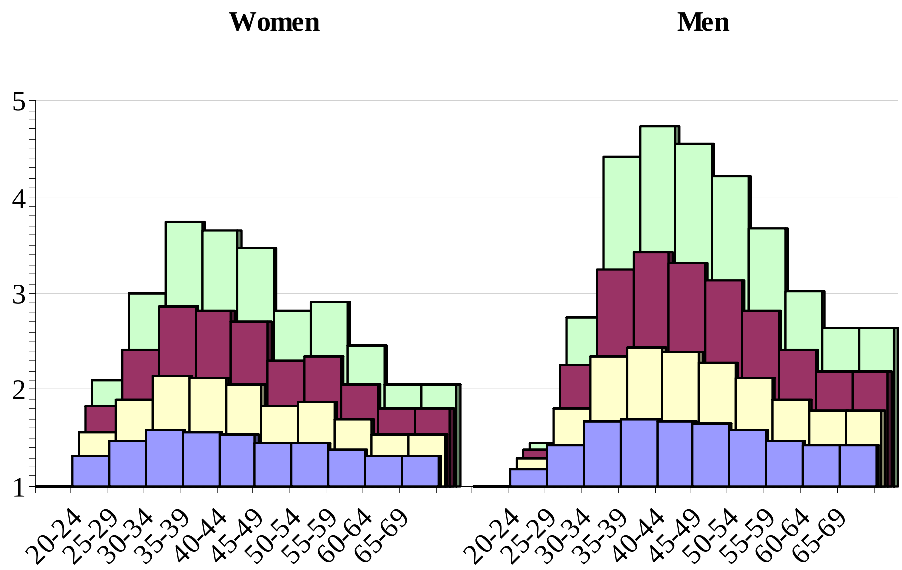
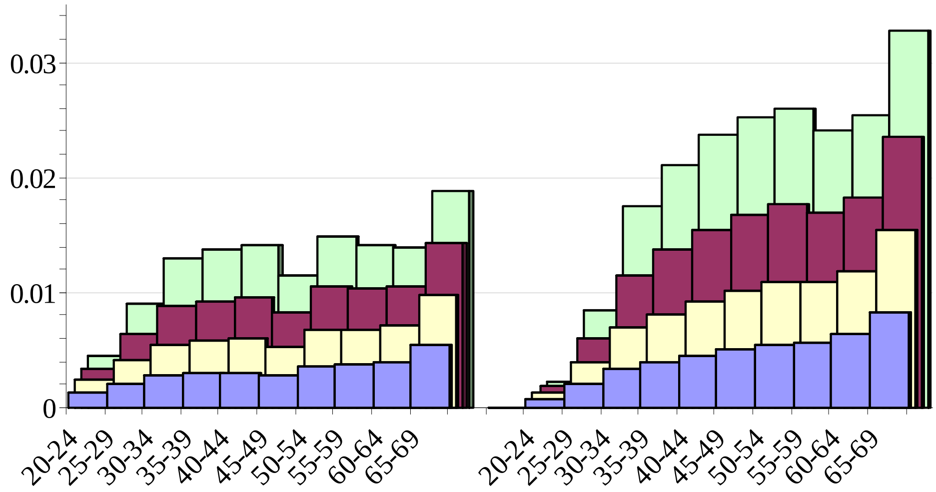
Orphanhood estimates
Sibling history estimates
Rwanda
Mozambique
Nigeria
Women's mortality 25-35
Women's mortality 25-40
Men's mortality 35-50

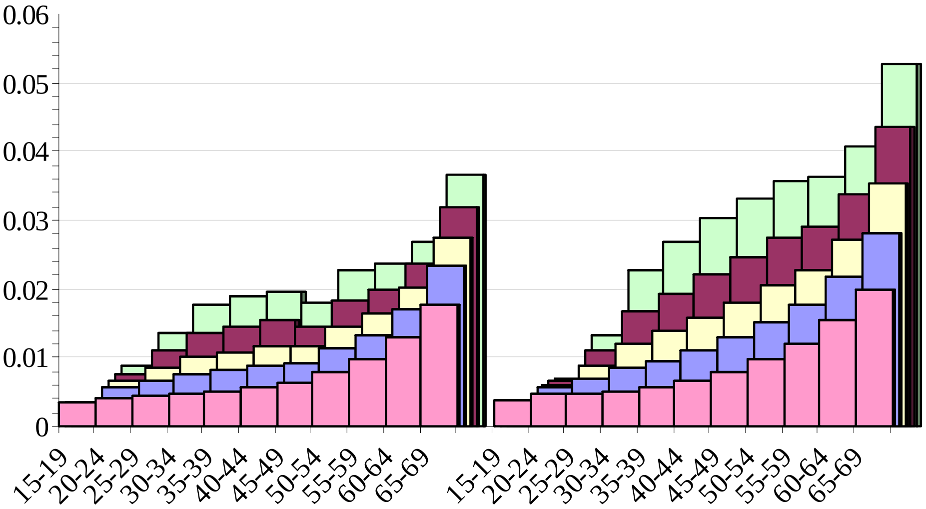

(a) Men
$_{45}q_{15}$
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-4
-2
0
2
4
6
8
10
12
14
16
Years into the AIDS epidemic
(b) Women
$_{45}q_{15}$
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-4
-2
0
2
4
6
8
10
12
14
16
Years into the AIDS epidemic
Benin
Burkina Faso
Cameroon
Central African Rep.
Chad
Côte d'Ivoire
Ethiopia
Guinea
Kenya
Malawi
Mali
Mozambique
Namibia
Nigeria
Rwanda
South Africa
Tanzania
Togo
Uganda
Zambia
Zimbabwe



a) Relative rise in mortality



b) Absolute rise in mortality



c) All-cause mortality

4 years 7.5 years 10 years 12.5 years 15 years