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IMPACT OF HIV ON MORTALITY IN SOUTHERN AFRICA: EVIDENCE FROM DEMOGRAPHIC SURVEILLANCE

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Seminar of the IUSSP Committee “Emerging Health Threats”
HIV, RESURGENT INFECTIONS AND POPULATION CHANGE IN AFRICA

Séminaire de la Commission de l’UIESP “Nouvelles menaces sanitaires”
VIH, INFECTIONS RÉÉMERGENTES ET CHANGEMENTS DÉMOGRAPHIQUES EN AFRIQUE

Ouagadougou, 12-14 February 2004 / 12-14 février 2004
Impact of HIV on Mortality in Southern Africa:
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Introduction
Sub-Saharan Africa is almost entirely without reliable routinely-collected vital statistics. The lack of such data has helped to the foster enduring scepticism of some scientists, policy-makers and commentators as to the severity of the HIV/AIDS epidemic in the continent. The more radical of these sceptics deny that AIDS is a new disease caused by HIV. They tend to reject the idea that mortality has risen massively in Africa in recent years and ascribe any increase in mortality that has occurred to developments such as increasing poverty or the spread of drug-resistant strains of existing infectious diseases. More moderate sceptics accept that HIV causes AIDS and that it is leading to mortality increase in Africa. However, they believe that the severity of the epidemic has been overestimated, sometimes accusing scientists and activists working on AIDS of “sexing up” the statistics on the epidemic to further their own careers (Malan 2003).

In the West, it was mortality statistics that provided the first reliable quantitative data on the spread of HIV. Considerable ingenuity has gone into developing methods for back-projecting HIV infections from AIDS deaths. In Africa, in the absence of functioning vital statistics systems, it has been necessary to work in the opposite direction. Estimates of the severity of the HIV/AIDS epidemic are made from epidemiological surveillance data and, in particular, data obtained by anonymous testing of blood samples taken from women attending antenatal clinics. Unfortunately, in most African countries these antenatal clinic surveillance data are not statistically representative of all pregnant women or even of those pregnant women who attend public-sector antenatal clinics. In addition, moving from an estimate of HIV prevalence among pregnant women to one of HIV prevalence among all women and among men, and then from these estimates to estimates of AIDS incidence, AIDS mortality and AIDS orphans, involves a long series of assumptions about the epidemiology and natural history of HIV. While both the sophistication of the modelling process and knowledge of the key epidemiological parameters involved in it have improved in recent years (UNAIDS Reference Group on Estimates Modelling and Projections 2002), estimates obtained in this way inevitably remain very
approximate. Thus, they remain open to attack by sceptical critics claiming that the numbers are either baseless or systematically and grossly exaggerated.

**Previous Research**
The only countries in mainland sub-Saharan Africa in which the civil registration system has so far yielded useful mortality statistics are Zimbabwe and South Africa (Dorrington et al. 2001; Feeney 2001). Moreover, even in these countries, registration of deaths is incomplete and the data require adjustment. In the absence of routine vital statistics, attempts have been made to estimate mortality trends since the onset of the HIV/AIDS epidemic using data collected in national censuses and Demographic and Health Surveys (Timæus 1998; Timæus 1999; Timæus and Jasseh 2003). Such data have their own limitations (Timæus 1991; United Nations 2002). In particular, they are subject to biases arising from errors in the retrospective reporting of events and provide no information on causes of death.

One further source of statistics on mortality in sub-Saharan Africa exists. It is demographic surveillance of the entire population of geographically defined local areas. Such demographic surveillance systems (DSS) now exist in many African countries. Many, but not all, of them collaborate in the INDEPTH network (INDEPTH Network 2002). While some African DSS are long established (Feachem and Jamison 1991), many were set up during the last decade or so. A number of these sites have specific remit to study the HIV/AIDS epidemic and several of them have introduced population-based HIV surveillance. Most use verbal autopsies to collect information on causes of death.

An early review the data on AIDS mortality being collected by DSS in Africa clearly documented their value (Boerma et al. 1998). It found that adult mortality had risen two- to three-fold in populations with only moderate HIV epidemics (<10 per cent). Thus, AIDS accounted for about half of all adult deaths in such populations. By combining DSS data on mortality with information on individual’s serostatus, Nunn et al. (1997) showed that mortality in the Masaka District of Uganda was eleven times higher in HIV positive adults than in HIV negative adults. Furthermore a comparison of the DSS-based mortality estimates for the study area with retrospective estimates, demonstrated that mortality among HIV negative adults remained similar to that in the population as a whole before HIV became prevalent (Timæus and Nunn 1997). Thus, the increase in adult mortality in the study area could be accounted for fully by the spread of HIV infection.

More recent studies based on DSS data have ended to confirm the conclusions of the initial reports. For example, a study in a rural area in north-western Tanzania with 7 per cent HIV
prevalence among adults aged 15-44, found that mortality was 15 times higher among HIV positive adults than in the HIV negative and that AIDS accounted for nearly half the deaths at ages 15-44 (Urassa et al. 2001). Moreover, in Rakai District of Uganda, with a prevalence of HIV infection of 16 per cent at ages 15-59, AIDS accounts for 73.5 per cent of adult deaths and the risk of dying of HIV positive adults is 20 times that of the uninfected (Sewankambo et al. 2000). Synthesizing the results of these studies and those from other DSS sites in Eastern Africa that have collected data on serostatus, Todd et al. (2003) estimate that the relative risk of dying among HIV positive, compared with HIV negative, adults is approximately 15 in African populations with moderate background mortality. Recent research has also confirmed the suggestion (Boerma et al. 1998) that the survival times of adults following infection with HIV in Africa differ little from those in Western populations prior to the introduction of antiretroviral therapy. Data from the natural history cohort linked to the Masaka DSS suggest that, after correcting for recruitment bias, the median time from infection to death among adults is about 8 years (Morgan et al. 2002; Whitworth et al. 2003).

In an important comparative study of the mortality data collected by INDEPTH sites, Sam Clark has attempted to identify clusters of mortality schedules and develop model life tables that embody these distinct age patterns of mortality (INDEPTH Network 2002). The analysis identifies seven such patterns. One of these is based largely on data from Bangladesh, however, and in two more it is only the mortality schedules for women that are distinctive. Pattern 5 is based almost entirely on data from a cluster of three Tanzanian sites that form part of the Adult Mortality and Morbidity Project (AMMP) - Dar es Salaam, Hai and Morogoro. By modelling these data, Clark identifies a distinctive pattern of mortality increase due to AIDS. Finally, by adding this “AIDS hump” in the age pattern of mortality to the Pattern 1 models, which are based on the largest cluster of empirical schedules, he produces models of all-cause mortality that for use in African populations in which AIDS deaths are exerting a marked downward pressure on life expectancy.

These models of the impact of AIDS are potentially of great value for forecasting future mortality and projecting the population in Africa. Empirically-based evidence as to the age-specific impact on mortality of AIDS could also help to calibrate the parameters of epidemiological models of the HIV epidemic. Thereby, it could contribute to improving understanding of age patterns of HIV incidence and survival times. In particular, mortality data may provide a far firmer basis than exists at present for assessing the severity of the epidemic among men as well as women. However, one important limitation of the INDEPTH models of the impact of AIDS is that they are based entirely on data from Tanzania. The age-specific
impacts on mortality of the HIV/AIDS epidemic is a function of the ages at which people become infected and of their subsequent survival times. As these characteristics of the HIV epidemic are likely to vary across Africa, variation in age patterns of mortality increase is also to be expected. Indeed, the INDEPTH data also yield a second cluster of mortality schedules that clearly include substantial AIDS mortality (Pattern 3, based on data from Agincourt in South Africa, Dar es Salaam, and Bandim, Guinea-Bissau). Thus, such variation certainly occurs. It is unclear either whether the pattern of AIDS mortality revealed by the Tanzanian data is typical of Africa or by how much age patterns of mortality increase in other parts of the region might differ from those in Tanzania.

**Scope of the analysis**

This analysis examines the increase in adult mortality associated with the spread of HIV/AIDS in Southern Africa. It has two specific objectives. The first is to examine the extent to which the age patterns of mortality increase in several Southern African populations share common features. In particular, it examines the extent to which patterns identified in the civil registration data for South Africa and Zimbabwe are confirmed by the results of active demographic surveillance. The second objective of the paper is to compare the impact of AIDS on mortality by age in Southern Africa with the model pattern derived from the AMMP data for Tanzania.

Death registration statistics for three years are analysed for South Africa - 1990, 1996 and mid-1999 to mid-2000. For Zimbabwe, registration statistics for 1986, 1992 and 1995 are used. These years are selected from among those for which data are available to span the period of rising mortality due to HIV/AIDS. Registration of deaths is incomplete in both countries and the mortality rates have been adjusted upward to correct for this (Feeney 2001; Timæus et al. 2001). As AIDS is seldom reported as a cause of death, AIDS mortality in both countries is inferred from the rise in mortality over time by making the assumption that mortality from other causes remained unchanged over the decade of interest. Partial empirical support for this assumption is provided by the lack of change in mortality rates in old age.

Data obtained through demographic surveillance of two sites in South Africa are included in the analysis. The first is the Wellcome Africa Centre for Health and Population site that covers part of Umkhayakude district in northern KwaZulu-Natal. This site uses verbal autopsies to identify causes of death. Using these diagnoses, one can calculate mortality rates for both all-cause and non-AIDS adult mortality (Hosegood et al. 2004 in press). At present, cause-specific data are available only for the first year of the study - 2000. The second South African DSS is the Agincourt study situated on the borders of Mpumalanga and Limpopo provinces. The mortality
The published data on Agincourt are not detailed enough to allow one to distinguish AIDS and non-AIDS mortality by age and sex from either cause-specific data or the evidence of mortality trends.

The final set of mortality data analysed here is based on neither civil registration nor demographic surveillance but on the church registers maintained by the Evangelical Lutheran Church in Namibia (ELCIN) in several parishes in the North-Western part of the country (Notkola et al. 2004 in press). About 80 per cent of the population of this part of Namibia belong to ELCIN. The congregations of the parishes studied do not represent a representative random sample of the population. Nevertheless, although the parishes are situated in diverse locations, mortality differentials between them are small. Thus, it seems unlikely that the mortality of the study population differs markedly from that of the general population of this part of Namibia. The dataset analysed here covers the years 1980-2000. Information on causes of death is not available. However, the mortality rates for the period up to 1993 show no evidence of being affected by AIDS deaths. Moreover, adult mortality was stagnating prior to the onset of the HIV epidemic (Notkola et al. 2000). Thus, once again, the rise in adult mortality between 1994-2000 and 1980-1993 is assumed to be due to AIDS.

**Results**

Figure 1 presents the increase in age-specific mortality associated with AIDS in the four populations where this can be netted out of the all-cause mortality schedule. As already noted, in Umkhayakude this is done using information on causes of death; elsewhere, it is inferred from mortality increase over time. Clearly, Umkhayakude in 2000 has the most severe epidemic, followed by Zimbabwe in 1995. In all the populations, AIDS mortality occurs at slightly older ages for adult men than for adult women. The absolute rises in mortality are somewhat larger for men than women. However, as the increase occurs at older ages for men than women, this does not necessarily translate into a greater number of AIDS deaths among men than among women.

The shape of the age pattern of mortality increase for women is very similar in all four populations. However the distribution is shifted about five-years downward in the national data for South Africa and five years upwards in North-Western Namibia compared with the other two populations. For men, both the shape and the location on the age scale of three of the distributions are very similar. However, the age pattern of mortality increase in the national data for South Africa is appreciably more dispersed than in the other populations.

As with Clark’s analysis of the INDEPTH data (INDEPTH Network 2002), it may be useful to employ Principal Components Analysis of the covariance matrix to attempt to identify a small
number of components that account for the variation between the 11 Southern mortality schedules for each sex. Because the set of schedules covers both those that include and those that exclude AIDS mortality in three of the four populations (the exception being Agincourt), it may be particularly easy to identify the component of variation in mortality associated with AIDS. Separate analyses are undertaken for men and women. The analyses are conducted on the logit probabilities of dying in each five-year age group ($q_{5x}$) of women from 5-9 to 60-64 and of men from 5-9 to 65-69:

$$0.5 \cdot \logit(q_{5x}) = \frac{s q_{5x}}{1 - s q_{5x}}$$

Each age group is weighted by the sum, across the populations, of the proportions of deaths in each population occurring in that age group.

The results of this analysis are shown in Table 1. Just two components for men and three components for women account for 98 per cent of the variation between the 11 mortality schedules for each sex. Examination of the component scores reveals that the first component, which accounts for most of the variation in the datasets, represents the common variation across the 11 mortality schedules in mortality by age (Figure 2a). As one would expect, men’s mortality rises more steeply with age than that of women. The second component is evidently linked to variation between the schedules in AIDS mortality. For both sexes the plot of the scores against age is n-shaped (Figure 2b). Thus, populations with a positive loading on the component have relatively high mortality in the central adult ages compared with adolescence and old age. The component for men is shifted toward older ages than the component for women and is also somewhat broader. For both sexes, the third principal component (not shown) appears largely to capture distinctive features of the mortality schedules for North-Western Namibia. For women, it has most effect on the mortality of those in their twenties and aged above age 55 (both of which are relatively low in Namibia). For men, this component is less important and largely affects the relative severity of mortality in the age group 20-24 years.

Returning to Table 1, the loadings of the different populations on to the first mortality component of mortality vary little across the 11 populations for either men or women. In contrast, the loadings of both men and women on the second mortality component are clearly related to the importance of AIDS mortality in the all-cause mortality schedule. The component loadings rise sharply over time in the mortality schedules of both sexes in Zimbabwe and South Africa and in the men’s schedules in North-Western Namibia. The loadings are also much higher in the all-cause mortality schedules for Umkhayakude than in the AIDS-free mortality schedules for this population. For women, the third mortality component also rises with time in the three
populations with repeated observations and is higher in the all-cause data for Umkhayakude. The decline over time in the loading on the second component in North-Western Namibia is matched by a particularly large rise in the loading on the third component. Finally, in most respects, mortality in Agincourt in the second half of the 1990s appears to have been intermediate in most of its characteristics to the national schedules for South Africa for 1996 and 1999-2000.

Inspection of Table 1 allows one to identify typical component loadings for, firstly, the mortality schedules that precede the onset of significant AIDS mortality in these populations and, secondly, the most recent data from them. The loadings on the first component are not associated clearly with those on the other components and average about 0.3. Treating North-Western Namibia as somewhat of an outlier, the loadings on the second component range from about -0.4 to 0.5 for men and from about -0.415 to 0.425 for women. For women, the loadings on the third component vary with those on the second one, rising from about -0.3 to 0.25 across this set of mortality schedules.

Using the loadings just listed, one can produce model age patterns of mortality in Southern Africa, as represented by these data, for both before the onset of the AIDS epidemic and according to the most recent data available (Figure 3). Like the original data, these model mortality schedules indicate that the age range over which mortality has risen and the modal age of that increase is about five years higher for men than women. The distribution for men also appears to be somewhat skewed towards older ages. Some of the erratic fluctuations in mortality between adjacent age groups in the upper part of the age range considered persist in the second component of mortality.

Figure 4 superimposes the age pattern of mortality without and with AIDS in appropriate INDEPTH model mortality schedules on to the age patterns of mortality in these Southern African models. Comparison of the results is complicated by the fact that non-AIDS mortality in Southern Africa rises much more sharply with age for both men and women than in the INDEPTH Pattern 1 models. Nevertheless, the location, spread and shape of the age patterns of mortality increase in the two models is clearly rather similar for both men and women. However, it appears that the may have been somewhat more increase in mortality in middle age in Southern Africa than in the AMMP data from Tanzania.

**Discussion**

The overall conclusion to be drawn from this analysis is that age patterns of AIDS mortality are rather similar in the different African populations considered. The patterns of mortality increase
in Zimbabwe between the mid-1980s and mid-1990s and in South Africa during the 1990s resemble each other. In neither case are the elderly affected. For women, no obvious discrepancy exist between the age pattern of AIDS mortality estimated directly from the verbal autopsies conducted in Umkhayakude and that inferred from the rise in mortality revealed by the national statistics for South Africa. The AIDS epidemic in Umkhayakude in 2000 is clearly more severe than that in the country as a whole. AIDS mortality may occur slightly later than it does nationally but, overall, it is the similarity of the age pattern of mortality increase in the two sets of data that is most striking. For men though, the national data for South Africa suggest a rather flat distribution of AIDS deaths across the central adult ages. This conflicts with the evidence both from Umkhayakude and from the other sites. This explanation could be that, following the upheavals associated with the collapse of the Apartheid system and establishment of democratic rule in South Africa, the incidence of violent deaths among young men declined markedly in South Africa, offsetting part of the rise in mortality from AIDS.

The rise in mortality due to HIV/AIDS occurs between ages 25 and 65 for adult men, with the greatest rises occurring at ages 35-44 years. The age pattern of mortality increase for adult women is offset downwards by about five years from that of men: it extends from about age 20 to about age 60, with a peak among women in their thirties. The increase in women’s mortality may be concentrated at slightly older ages in North-Western Namibia than in Zimbabwe or South Africa. If so, this is consistent with what is known about ages at first sexual intercourse in Namibia and the other two countries from the results of Demographic and Health Surveys. However, the pattern of increase in men’s mortality revealed by the Namibian data is very similar to those in Umkhayakude and Zimbabwe.

The principal components analysis suggests that the AIDS component of adult mortality in Southern Africa age pattern is similar to that in the INDEPTH Pattern 5 model life tables based on AMMP data from Tanzania. The similarities between the left-hand sides of the “humps” in the mortality schedules produced by AIDS is particularly close. However, the death rates from AIDS among women aged 40 or more and men aged 50 or more may be higher in Southern Africa than in Tanzania. This might reflect differences in patterns of sexual activity between these two regions of Africa. For example, it would be consistent with higher levels of extra-marital sexual intercourse in Southern Africa. Alternatively, it might just reflect the relatively recent onset of the HIV/AIDS epidemic in Southern Africa (together with the time since the data were collected in Zimbabwe). For example, infection of older adults with HIV may be a feature of the early years of the epidemic. As the epidemic matures, HIV infections may become concentrated among new cohorts of young people commencing sexual activity, with those prone
to high-risk behaviour being selected out of the population at risk too quickly to give rise to many infections at older ages.

In summary, the overall impression to be gained from this analysis is that age patterns of mortality increase due to AIDS are rather similar across Africa. This suggests that it may be possible to develop a simple one-parameter model of the bulge in age-specific mortality schedules produced by AIDS which is adequate for modelling and projection purposes. This should be based on a broader set of empirical data than those generated by the AMMP site in Tanzania. Nevertheless, it seems unlikely that the final models will differ greatly from those published in the INDEPTH volume or presented here.
Table 1: Principal components analysis of 11 Southern African mortality schedules: loadings on the first and second components for each sex

<table>
<thead>
<tr>
<th>Population and year</th>
<th>Women (5-64 years)</th>
<th>Men (5-69 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Zimbabwe 1985</td>
<td>0.3272</td>
<td>-0.2042</td>
</tr>
<tr>
<td>Zimbabwe 1992</td>
<td>0.2954</td>
<td>0.1876</td>
</tr>
<tr>
<td>Zimbabwe 1995</td>
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<td>0.4327</td>
</tr>
<tr>
<td>South Africa 1990</td>
<td>0.3773</td>
<td>-0.2484</td>
</tr>
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<td>South Africa 1996</td>
<td>0.3430</td>
<td>0.0215</td>
</tr>
<tr>
<td>South Africa 1999/2000</td>
<td>0.3011</td>
<td>0.2988</td>
</tr>
<tr>
<td>Umkhayakude 2000, non-AIDS</td>
<td>0.3313</td>
<td>-0.2237</td>
</tr>
<tr>
<td>Umkhayakude 2000, all-cause</td>
<td>0.3044</td>
<td>0.4268</td>
</tr>
<tr>
<td>N.W. Namibia 1980-93</td>
<td>0.1393</td>
<td>-0.0278</td>
</tr>
<tr>
<td>N.W. Namibia 1994-2000</td>
<td>0.2478</td>
<td>-0.5855</td>
</tr>
<tr>
<td>Agincourt 1995-9</td>
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<td>-0.0928</td>
</tr>
<tr>
<td>Percentage of variance explained</td>
<td>87.2</td>
<td>6.1</td>
</tr>
</tbody>
</table>
Figure 1: Increase in adult mortality by age in populations in which HIV has become prevalent

a) Men

Sources: Umkhayakude (Hosegood et al. 2004 in press); Zimbabwe (Feeney 2001); North-Western Namibia (Notkola et al. 2000); South Africa (Timæus et al. 2001).

b) Women

Sources: Umkhayakude (Hosegood et al. 2004 in press); Zimbabwe (Feeney 2001); North-Western Namibia (Notkola et al. 2000); South Africa (Timæus et al. 2001).
Figure 2: Principal components of 11 Southern African mortality schedules for each sex

a) First component

b) Second component
Figure 3: Age-specific probabilities of dying, principal component models

a) Men

b) Women
Figure 4: Comparison of the Southern African and In-Depth models

a) Men

Source: INDEPTH models (INDEPTH Network 2002).

b) Women
References


