Original article

Life table estimates of adult HIV/AIDS mortality in Addis Ababa

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Abstract

Background: With the expansion of antiretroviral treatment in the country, HIV prevalence figures alone, are expected to become insufficient for monitoring the HIV/AIDS epidemic

Objective: To develop a life table method for estimating AIDS mortality based on a surveillance of deaths at burial sites in Addis Ababa.

Methods: An empirical life table for 2001 based on observed deaths and the projected population is matched with a model life table on an age range where AIDS mortality is minimal. Excess mortality in adulthood is attributed to AIDS.

Results: Between 54.7 and 62.4% of adult deaths in Addis Ababa (age 20-64) are attributed to AIDS. The absolute numbers of AIDS deaths for the year 2001 is estimated between 7,000 and 9,000. Estimates of the absolute number of deaths are sensitive to under-reporting of burials and therefore on the conservative side. In terms of the share of AIDS attributable mortality, women are worse affected than men. The absolute number of AIDS deaths is higher for men than for women.

Conclusion: Life table methods corroborate earlier estimates of AIDS mortality based on other methodologies. Burial surveillance data used as an input to life table methods may be used for monitoring the demographic impact of AIDS as well as the population level effects of the provision of antiretroviral treatment. [*Ethiop.J.Health Dev.* 2006;20(1):3-9]

Background

AIDS mortality data −as as opposed to HIV prevalence data− are hard to come by. The main obstacle to monitoring adult AIDS mortality in developing countries is the absence of vital statistics (1-6). The situation in Ethiopia is very similar to the rest of sub-Saharan Africa in the sense that morbidity and mortality estimates have to be derived from scattered sources that include statistics from governmental health facilities; the 1984 census that included a question on deaths in the household in the year prior to enumeration (7); a sample vital registration survey in 1998/9 (8); the 2000 Ethiopia Demographic and Health Survey (DHS) (9); and occasional morbidity or mortality surveys. So far, the lack of a continuous registration of deaths has hardly complicated tracking of trends in the HIV/AIDS epidemic as prevalence rates were, and still are, the most important indicator for monitoring purposes. With the expansion of antiretroviral treatment (ART), however, prevalence rates are expected to lose informative value because they reflect the magnitude of the epidemic as well as efforts to provide ART on a larger scale. A different approach to monitoring the impact of AIDS is thus needed and this study attempts to develop a simple method based on burial surveillance data and life table techniques.

Data

The burial surveillance was initiated at all cemeteries in Addis Ababa in February 2001 and a total of 21,274 deaths were recorded in one year. During that period, the surveillance covered 55 Orthodox, nine Muslim, one Catholic, one Jewish and eight municipal cemeteries. The largest of the municipal cemeteries, the *Baytewar* cemetery, accommodates bodies of people who have no close relatives or friends to facilitate their funeral[1]. In 2001, the *Baytewar* cemetery alone accommodated 14% of burials in the city. Many these are corpses of infants delivered by obstetrics wards of hospitals. Most bodies (61.5%) buried at *Baytewar* remain unidentified.

The surveillance is assisted by cemetery clerks who were trained in a two-day workshop. Twelve supervisors closely monitor the work of the clerks and report to the project office on a weekly basis. The cemetery clerks collect information on the date of burial, the age, name, sex, address, and presumed cause of death (i.e. the lay report of the cause of death) from relatives or close friends while they are making arrangements for burial. Marital status, region of birth, ethnicity and religion were added to the list at a later stage. Region of birth is used in this paper to distinguish lifetime migrants from those who are born in Addis Ababa.

Because life table methods are used to estimate HIV/AIDS mortality, the quality of age reporting is of primary concern. For the first year of the surveillance, 6.3% of the records had missing values for age. Excluding *Baytewar*, only 1.5% of cases have missing values for age. Age heaping is serious (Whipple Index of 283) and the ages are therefore grouped into five-year intervals. Cubic spline smoothing is done on the age

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[1] *Baytewar* is an Amharic word that is used to refer to a stranger or someone who is socially isolated.

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distribution of deaths above age 50 because this age range is characterised by a strong digit preference for 0. Age over-reporting is a potentially more serious problem because it leads to underestimates of mortality (10;11). Both in the burial surveillance data as well as in other published reports on mortality for Addis Ababa, there is evidence of age over-reporting. For example, the reported value of 13.5 for e_{70} in a life table for 1984 for males (7) would imply an e_0 value of 76 and 80 years in the North and West model life tables respectively. This is an unrealistic value and probably not only due to age over-reporting but also to under-reporting of deaths. Whatever the cause, it casts doubt on the utility of old age mortality schedules for any analytical purpose.

Estimates of the crude death rate (CDR) based on the first three months of surveillance and a population estimate for 2001 (CDR_{male}=9.5 per 1000, CDR_{female}=7.1 per 1000) are close to those implied in official population projections (12), but are nonetheless low for a population that is severely affected by HIV/AIDS. Under-reporting of infant and child deaths is an important part of that problem. The estimated probability of dying before the age of 5 is only just above half of that obtained in the DHS survey (9), and adjusting for the under-reporting for infant deaths alone would raise the overall CDR by more than 1 per 1000. The under-reporting of infant deaths is the main reason why we focus on adult mortality.

The registration of adult burials does not perfectly represent adult mortality in the city either[2]. One source of bias is that the project only registers regular Addis Ababa residents who are buried inside the territory of the city. This strategy misses out on all residents buried elsewhere and is not compensated by non-residents buried in Addis Ababa[3]. Other sources for under-reporting are the return of terminally sick migrants to their families for care (13), the repatriation of bodies for burial, and, possibly also illegal burials[4]. The only category of burials outside the capital that are represented in the surveillance is that of Orthodox Christians that are referred to sacred burial sites outside Addis Ababa, because they are usually first registered in one of the local churches.

Methods

The approach to estimating AIDS from these data is straightforward: 1) an empirical life table for 2001 is constructed using burial surveillance data and projected 1994 census data; 2) the empirical life table is matched with Coal-Demeny model life tables (14) on an age range that is not affected by AIDS mortality[5]; and 3) excess adult mortality is assigned to HIV/AIDS. The parameter used for matching both life tables was the probability of dying between the ages 8 and 18 (10q8). This age range is chosen because AIDS mortality in this interval is negligible (15), and because it is not likely to be affected by extreme forms of age misreporting. An attractive feature of this procedure is that it automatically accounts for under-reporting of deaths as long as the under-reporting in each age group is proportional to the under-reporting in the age range that is used for matching (see also the notes to table 1). For the same reason we also chose to disregard cases with missing information on sex and age in the life table analysis.

A first weakness of this approach is that relatively few deaths occur in the age range from 8-18 (2.4% in the burial surveillance data). The results of this study are, therefore, based on the reliability and completeness of reporting for a relatively small fraction of the deaths. Secondly, not all change in mortality can be automatically assigned to HIV/AIDS and temporary fluctuations in the frequency of external injuries, for example, may bias AIDS estimates upward or downward depending on the age groups wherein it is concentrated. A third issue is that we need to make assumptions about AIDS mortality in order to make projections of the population at risk. This problem is accommodated by an iterative procedure: first, the population at risk is projected without assuming an AIDS effect and the resulting estimates of age-specific AIDS mortality rates are subsequently used as an input to run the projections again until the difference between two subsequent projection rounds is negligible. In these projections it is assumed that AIDS mortality rates increase exponentially. The baseline population for the projections is derived from the 1994 census report (12). The fertility assumptions come from the DHS survey of 2000 (9) and, in accordance with the official high-range population projections, net immigration is assumed to remain constant at the 1994 level (12).

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[2] There are two potentially useful strategies for identifying the completeness of the burial registration that will not be further explored in this paper. Indirect methods often assume stability and/or that the population is closed to migration (23,24), and these assumptions are too stringent for the current context. A second approach is to identify deaths in the community through an independent system and assess to what extent these deaths can be traced in the burial registration system. Preston labeled this as a direct method for assessing the completeness of a death registration system (24) and it has previously been applied in Abidjan and Dakar (25). We hope to pursue a similar effort in the future.

[3] In the third year of the surveillance this policy was changed to record all burials in Addis Ababa territory.

[4] We are aware of one cemetery where burials continued even though it was officially closed. In that case, youngsters from the neighbourhood arranged with relatives of the deceased to prepare the grave against a small compensation.

[5] A model life table is chosen because no reliable life table exists for the pre-AIDS period. A 1983-life-table based on a census question of the number of household deaths (7) in the year preceding the census is characterized by serious under-reporting of mortality at older ages (see earlier). The study only reported results using the Coale-Demeney West model life table. The sensitivity of the results to the use of other model life tables were tested but the results did not change much.

This study also attempts to quantify (and correct) bias arising from the return of terminally sick migrants or the repatriation of bodies to places of origin. To that end, the representation of lifetime migrants in the burial registration is compared with their share in the population. Figure 1 illustrates the age-specific net difference in the percentage of migrants in the population as projected from the 1994 census data. In early adulthood, the under-representation of migrants in the burial surveillance is possibly related to the self-selection of migrants based on their health status; at older ages this argument weakens. It would not explain why an important gender difference persists above age 50 either. One partial explanation is that the deficit of migrant deaths is due to the return of terminally sick migrants to their families for care (i.e., a salmon effect) as well as by the return of bodies for burial in their region of origin. Such an explanation also accommodates sex differences at older ages because it rests on the idea that male migrants retain greater ties with their families while women in patrilineal societies become more fully absorbed by the households they marry into. A competing or complementary explanation for the more moderate under-representation of female compared to male migrants is higher AIDS mortality because migrant women may resort to various forms of commercial sex work to make a living in the capital (16). Both arguments cannot be further substantiated at this stage and necessarily remain hypothetical. For illustrative purposes, one adjustment factor (adj. 1) for the under-reporting of deaths will be calculated based on the first of these two explanations. It assumes that the burial surveillance is 90% complete and distributes the additional deaths proportionally to the sex and age pattern of the deficit of migrants in the burial surveillance.

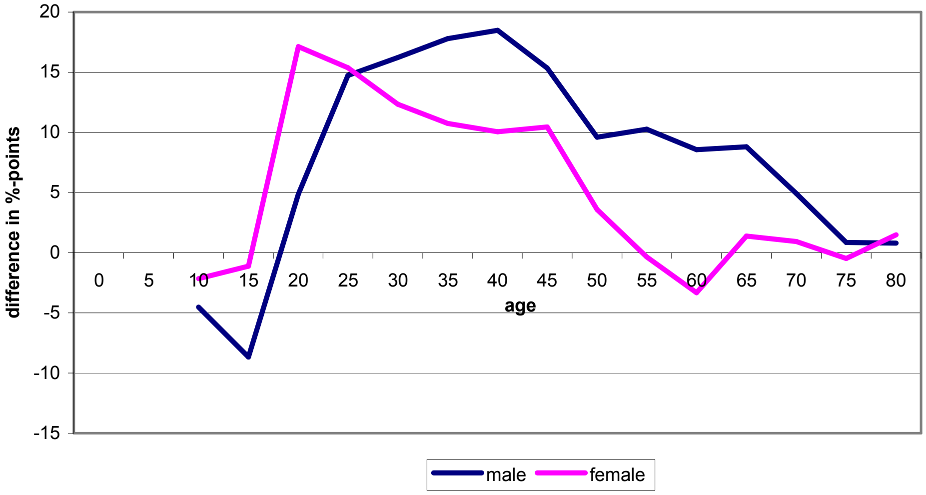

Figure 1: **Difference in the age-specific percentage of migrants in the population and burial registration (positive values indicate that the percentage migrants in the population is higher than in the burial registration)**

Results

The empirical mortality schedules in figure 2 are matched with the Coale-Demeney model West life table (level 20) on $_{10}q_8$. The death rates of the model life table are proportionally adjusted to provide a perfect match. The adjusted level 20 of the West model life table has an implied life expectancy of 63.6 and 69.4 years for males and females and that is three to four years higher than the life expectancy implied in official mid range population projections for the period 2000-05[6]. This result is indicative of under-reporting in the burial surveillance. To the extent that the under-reporting of deaths (including cases omitted because of missing values for age or sex) in the age range between 8 and 18 is proportional to that in other ages, estimates of age-specific AIDS mortality rates will not be affected.

Figure 2 is clearly suggestive of the AIDS-hump of mortality in early adulthood. The right panel of figure 2 indicates that AIDS mortality rates are markedly higher for men than for women with the exception of early and late adulthood. The fact that AIDS mortality affects women earlier in life than men is consistent with other studies (17). We do, however, suspect that higher AIDS mortality of women above age 50 may be an artifact of the greater under-reporting of male deaths due to the sex-selective return of sick migrants and the repatriation of bodies for burial. Once adjusted for the possible under-reporting of migrants in the burial surveillance discussed earlier, the disadvantage of women at older ages disappears (Figure 3).

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[6] Except for the effect of AIDS mortality that is implied in the baseline population, these projections do not account for AIDS mortality.

This sex and age patterns of AIDS mortality is pushed to an extreme if the Addis Ababa born population (considered non-migrants) are singled out. This is done in figure 4. Among men, adult AIDS mortality is markedly higher for non-migrants. Part of the story is the healthy migrant effect (including lower HIV infection rates because prevalence is lower in rural areas (18)), but the small difference between female migrants and native born women may indicate that male migrants return more often to their places of origin just before or after death. The explanation that migrant women are often drawn into prostitution is also consistent with these results.

In Table 1, the summary statistics of AIDS mortality are compared with estimates based on the physician review of adult verbal autopsies (2001, N=200) and a method based on lay reports of the cause of death (19). The percentage of adult deaths (aged 20-64) attributable to AIDS ranges from 54.7 to 62.4% with a slightly higher share for women than for men. In the age range 20-54, the estimated share of AIDS deaths varies between 61.0 and 68.3%. An alternative estimate of the share of AIDS mortality based on epidemiological projections for the year 2000 is 60% for the age group 15-49 (20). Our results translate into an estimate of the total number of adult AIDS deaths in 2001 that ranges from close to 7,000 to around 9,000. Here, the figures are higher for men than for women. The higher number of male AIDS deaths in combination with a lower share of AIDS deaths is likely due to greater mortality among men because of other causes than AIDS (e.g., external injuries). Worth noting is that our estimates of the absolute number of deaths are roughly half of those reported by the Ministry of Health (MOH) (21). Admittedly, our estimates of AIDS deaths are dependent on the completeness of the burial surveillance and are rather conservative. They nonetheless suggest that AIDS mortality estimates based on extrapolations from antenatal sentinel surveillance sites (the method used by the MOH) need to be interpreted with the necessary caution.

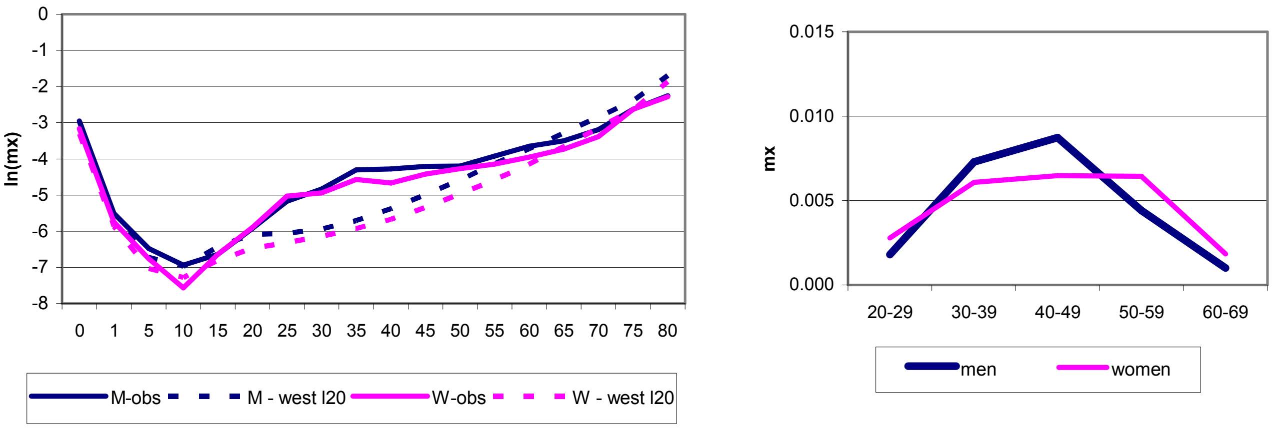

Figure 2: **Left: comparison of empirical age-specific death rates with those from the Coale-Demeny model west life table. Right: age-specific AIDS mortality rates**

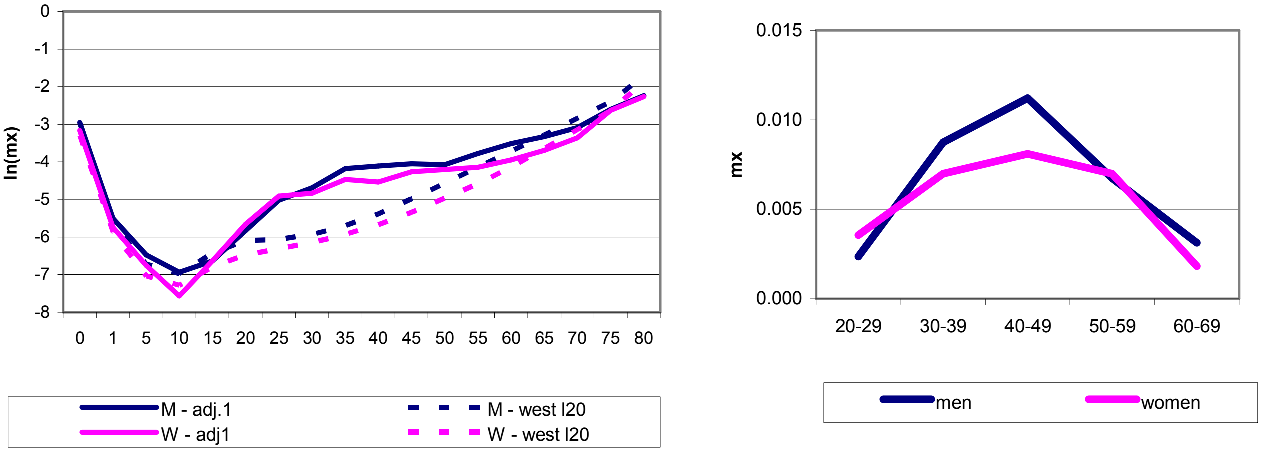

Figure 3: **Left: Comparison of empirical age-specific death rates (adjustment 1) with those from the Coale-Demeny model west (level 20). Right: Age-specific AIDS mortality rates under adjustment 1**

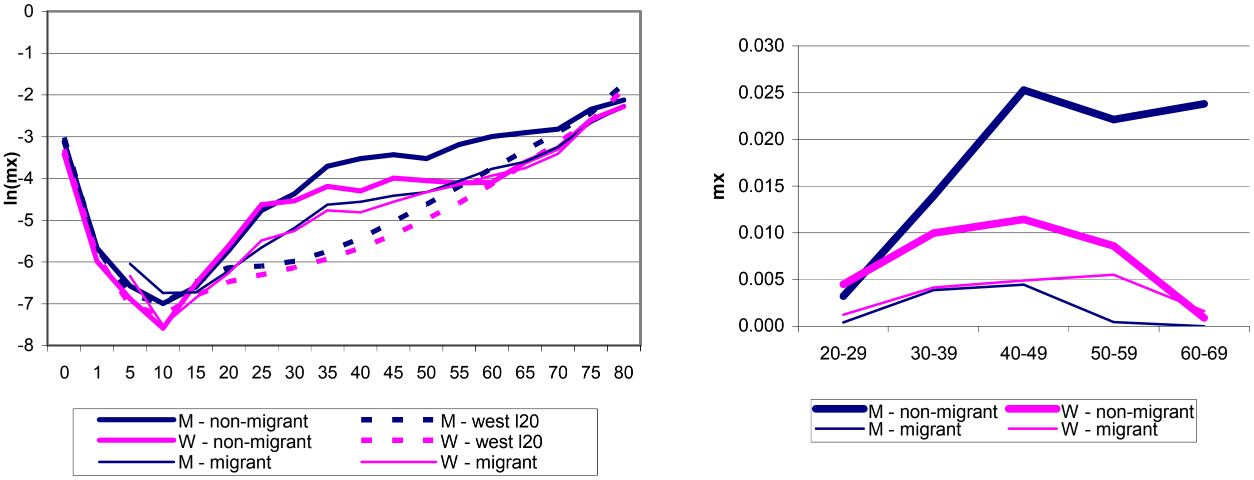

Figure 4: **Left: Comparison of empirical age-specific death rates for the Addis Ababa born population with those from migrants and the Coale-Demeny model west life table (level 20). Right: Age-specific AIDS mortality rates for the Addis Ababa born population and migrants**

Table 1: **Summary indicators of adult AIDS mortality using different estimation methods**

% of deaths due to AIDS		**Life table**		**Lay diagnosis method**	**Verbal autopsy estimate**
		Observed	**Adjusted**		
Men					
	20-54	57.5	63.0	66.0	64.7
	20-64	50.3	56.7	60.5	58.4
Women					
	20-54	64.8	69.0	70.0	72.4
	20-64	59.8	64.0	61.9	67.2
Total					
	20-54	61.0	65.8	67.9	68.3
	20-64	54.7	60.0	61.2	62.4

AIDS deaths		**Life table**		**Lay diagnosis method**		**Verbal autopsy estimate**	
		Observed	**Adjusted**	**Observed**	**Adjusted**	**Observed**	**Adjusted**
Men							
	20-54	3315	4167	3802	4365	3727	4279
	20-64	3470	4488	4171	4787	4027	4621
Women							
	20-54	3326	4025	3592	4082	3716	4222
	20-64	3471	4233	3659	4092	3972	4442
Total							
	20-54	6641	8192	7394	8447	7443	8501
	20-64	6941	8721	7830	8879	7999	9063

Notes: 1) estimates of the absolute number of AIDS deaths were obtained by multiplying sex and age-specific AIDS mortality rates by the total number of deaths in their respective age and sex groups. Estimates of age and sex specific AIDS mortality rates (as well as estimates of the share of AIDS deaths) are only affected by under-reporting of deaths that is disproportional to the under-reporting in the age group 8-18. Estimates of the absolute number of deaths are affected by every form of under-reporting. 2) verbal autopsy estimates and estimates based on the lay diagnosis =method are obtained from, or were calculated using methods reported in (19).

Conclusion

That AIDS has an enormous impact on adult mortality in Addis Ababa is beyond doubt. We estimate that more than one out of two adult burials (age 20-64) in the capital has AIDS as the underlying cause and this is corroborated by estimates based on other methodologies. Even though this picture is gloomy, the worst is yet to come. If we are now witnessing the deaths of adults infected in the early 1990s, they could be expected to increase even more as the incidence only started declining in the late 1990s (22). The expansion of antiretroviral treatment programs may, of course, contain or even reverse that trend.

Our results also point to an intriguing interaction between the effects of gender and migration on AIDS mortality. In general, the influx of migrants depresses AIDS mortality rates because prevalence rates are lower in the countryside, but this pattern is more explicit for men. The difference in mortality rates between migrant and non-migrant women is much smaller and that could indicate that female migrants are exposed to a higher risk of infection; possibly because of prostitution. The difference in mortality patterns between migrants and non-migrants is also consistent with the hypothesis that male migrants are more likely to return home either for care when they are sick, or to be buried when they die.

The data and methods used in this paper are not highly refined and rely on a few crucial assumptions, but the relative consistency with other estimates strengthens our belief that they capture the order of the magnitude of the epidemic (a notable exception being the discrepancy with the MOH in the estimate of the absolute number of AIDS deaths). Regardless of its accuracy in providing a reliable point estimate of the level of AIDS mortality, burial surveillance data will prove useful for monitoring trends in AIDS morality as well as the population level impact of the provision of antiretroviral treatment. The availability of new census data in combination with efforts to assess the nature and scale of under-reporting in the burial surveillance will strengthen the quality of our estimates of AIDS mortality in the future and will add to the value of burial surveillance data as a partial substitute for a vital registration system.

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