The impact of HIV/AIDS on adult mortality in Zimbabwe

Running head: Adult mortality in Zimbabwe

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Abstract

Objective: To assess the impact of HIV/AIDS on changes in adult mortality in Zimbabwe from 1980 through 1997.

Design: Estimate trends in age-specific death rates and life table survival probabilities from all available data. Compare estimates to assess quality and draw conclusions about trend. Infer impact of HIV/AIDS from age pattern and trend of age-specific death rates.

Method: Estimate changing completeness of death registration by sex. Calculate death rates for ages 15-64 and probabilities of death ${}_{35}q_{15}$ and ${}_{35}q_{30}$ from adjusted registration data and from household deaths data. Estimate probabilities of death from data on survival of parents (${}_{35}q_{30}$) and siblings (${}_{35}q_{15}$).

Results: Age-specific death rates and probabilities of death rise sharply (200-300%) for both males and females. Consistency of estimates from vital registration, household deaths and survival of siblings suggests reasonably accurate results. Estimates from survival of parents are more problematic but indicate rising mortality in later years. There is no sign of deceleration in the rise of mortality risks through 1997.

Conclusions: There was a massive increase in adult mortality risks in Zimbabwe between 1986 and 1997. The evidence that these increases are due to HIV/AIDS is circumstantial, but very strong. Vital registration data have been under-utilized in assessing the demographic impact of HIV/AIDS.

Keywords: HIV/AIDS, adult mortality, less developed countries, Zimbabwe, Africa, vital registration, demographic impact

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Introduction

Deficiencies of national statistics in countries most severely affected by HIV/AIDS make it difficult to assess the impact of the epidemic on mortality. When working with limited and defective data it is important to utilize all available sources of information. This report analyzes all available national level data on adult mortality for Zimbabwe, assesses the quality of the various data sources, and presents estimates of changes in adult mortality through 1997.

Previous studies have made little or no use of the death registration data available for Zimbabwe, which turn out to be an exceptionally important source of evidence. Deaths are incompletely reported, of course, but methods are available to estimate and correct for under-reporting. These methods may be extended to estimate changing completeness of registration over time. This is important because the evidence indicates that completeness of death reporting in Zimbabwe has improved substantially in recent years.

Materials and methods

The measurement of mortality risks is reasonably straightforward when the vital statistics systems produces regular and complete reports of annual deaths classified by age and sex. This is virtually never the case in developing countries, in which vital registration is either lacking altogether or fails to capture a large fraction of deaths.

A limited number of expedients for estimating adult mortality are available in such situations. Deaths not captured by the vital registration system may be estimated and registered deaths adjusted for under reporting. Retrospective reports of deaths may be obtained from population censuses and surveys. Probabilities of death may be estimated from information on survival of parents and siblings collected in censuses and surveys. Zimbabwe is unusual in having the data necessary for pursuing all three of these approaches.

Vital registration data

No regular publications on numbers of registered deaths in Zimbabwe are issued, so far as we are aware. Deaths classified by age and sex for 1982 and 1986 are given in the United Nations Demographic Yearbooks for 1985 and 1994 [1, 2], respectively, however, and a query to the Zimbabwe Central Statistical Office from the United Nations Population Division (see Acknowledgements) in January 1999 resulted in the provision of similar but unpublished data for 1990-1992 and 1995. It is not known why data for other years are not available.

Several methods exist for estimating completeness of reported deaths by exploiting the partial redundancy between age-sex distributions obtained from two successive population censuses and deaths during the intercensal period classified by age and sex. Incomplete reporting in the population censuses poses a further problem, but methods exist for simultaneously estimating differential completeness of census enumeration and completeness of reports of intercensal deaths relative to the population census counts. The method used here is a variant of one proposed by Brass [3]. The criticism of Trussell and Menken [4] is addressed by using the method iteratively, adjusting the second census age distribution for relative completeness of enumeration at each iteration.

Estimates of completeness of death registration and census enumeration are all relative to completeness of enumeration in one or the other of the censuses (which census is a matter of choice). This is what is wanted, for the purpose of calculating death rates, for if adjusted deaths and population numbers are all constant multiples of the corresponding true values, rates calculated from these adjusted numbers will be correct.

Zimbabwe conducted population censuses as of 18 August 1982 and 18 August 1992. The 1982 age-sex distribution is available in the 1989 Demographic Yearbook [5], the 1992 distribution in one of the census reports [6]. Because the death registration data is available only for select years during the intercensal period, it is necessary to estimate numbers for the remaining years. This is done by averaging of registered deaths in surrounding available years. Intercensal registered deaths are calculated from these numbers with proration of deaths in census years.

Estimation of changes in completeness of reporting begins with the calculation of unadjusted age-specific death rates for males and females based on registered deaths for available years. Denominators are calculated by exponential interpolation between the 1982 and 1992 census age-sex distributions and between the 1992 census and 1997 intercensal survey age-sex distributions.

The unadjusted death rates for ages 10-14 show substantial increases for both males and females between 1986 and 1995. Since little impact of HIV/AIDS on mortality risks for this age group is expected during this period, these increases suggest that completeness of death reporting improved during the intercensal period. To adjust for changing completeness of reporting it is assumed that death rates for the 10-14 age group were constant during 1986-1995. This provides factors expressing completeness of registration in 1990-1992 and 1995 relative to completeness of registration in 1986. Differences between the male and female factors are averaged using the geometric mean to give a single relative completeness factor for each year.

The level of completeness of enumeration for each year is then expressible as an initially unknown common factor times relative completeness for this year. This common factor is determined by requiring intercensal deaths calculated by applying the adjustments for changing completeness of enumeration to equal intercensal deaths estimated for the intercensal period. Completeness of registration for 1995 was estimated by extrapolating the trend of improvement between 1986 and 1992.

Numbers of registered deaths are then adjusted for incomplete reporting and used to compute adjusted age-specific death rates for males and females for quinquennial age groups (to 75+) beyond age 5. Life tables beginning at age 5 are then constructed, from which the probabilities of death ${}_{45}q_{15}$, ${}_{35}q_{15}$ and ${}_{35}q_{30}$ are computed (${}_{n}q_{x}$ denotes the conditional probability of dying before age x+n given survival to age x). The first of these is computed because it has become a semi-standard indicator of adult mortality [7, 8], the second two for comparison with estimates derived from survival of relatives.

Household deaths data

Population censuses and surveys may include questions on the numbers of deaths that occurred to members of households during the year or other period prior to enumeration. Such “household deaths” data mimic the information collected by a vital registration system in giving numbers of deaths classified by age and sex. They differ in providing deaths for a period (most often the year) prior to the enumeration, rather than for a calendar year, and in being available intermittently, generally at intervals of 3-5 years or longer, rather than annually.

There is unfortunately no generally recognized survey of the use of household deaths data. Gross under-reporting of deaths is common, but over-reporting of deaths may occur as well. Performance of the questions is difficult to assess systematically because poor results are less likely to be published in census and survey reports and less likely to be the subject of research reports. Inaccurate reporting derives from simple failure of respondents to report known deaths, from memory failure (not so much the occurrence of a death, but of whether or not it occurred during the stipulated reference period) and from confusion over household membership. Methods similar to those used to estimate completeness of death registration data may be used to assess the quality of reporting, more or less successfully according to circumstance.

No question on household deaths was included in the 1982 census of Zimbabwe but data are available from the 1992 census and the 1997 intercensal survey (they may exist for the 1987 survey as well, but were not available for this study). These data are used without adjustment because the analysis suggests that they were reasonably accurately reported.

Parental survival data

Adult mortality may be estimated from reports on the survivorship of mothers and fathers. The 1982 and 1992 censuses of Zimbabwe included questions on the survivorship of parents [9, 10], as did the 1997 intercensal survey.

The responses to the question on survival of mother provide numbers of persons classified by age in five year groups and survivorship of mother (surviving, deceased, not reported), and similarly for the question on survival of father. The method described in Timæus [11] is applied to yield: (i) estimates of female conditional probabilities of survival from age 25 to ages 35, 40, ..., 80 from the proportions of persons in the 5-9, 10-14, ..., 50-54 age groups with mother surviving, respectively; and (ii) estimates of male conditional probabilities of survival from age 35 to ages 45, 50, ..., 75 from the proportions of persons in the 5-9, 10-14, ..., 40-44 age groups with father surviving.

The estimation equations for females require an estimate of the mean age of female births during any given year. This is calculated as the mean of the births occurring during the year prior to the 1992 census [6], obtained from a question on births to households in the year prior to the enumeration. Similarly, the estimation equations for males require an estimate of the mean age of male births during any given year. This is calculated as the mean age of female births plus the difference between the average age of female and male births, estimated as the difference between mean age of marriage for males and females calculated from 1992 census data on martial status [6].

The dating procedure developed by Brass and Bamgboye [12, 13] is used to assign each estimated conditional survival probability for males and females to a point in time at which it applies. All probabilities are translated to ${}_{35}q_{30}$ using model life tables [1], this statistic chosen to maximize the robustness of the translation.

In this way data on survival of parents from each of the three available sources are made to yield a time series of estimates of male and female ${}_{35}q_{30}$ values. A “two census” variant of the estimation procedure that produces a single estimated adult mortality level [14] was also applied to the data for 1982-92 and 1992-97.

Sibling survival data

Adult mortality may also be estimated from reports on the survivorship of brothers and sisters. The 1994 Demographic and Health Survey (DHS) of Zimbabwe included questions on the survivorship of siblings [15]. No sibling survival data was published in the DHS report, but special tabulations are available. The sibling survival data may be used to estimate probabilities of death in the same way as the parental survival data, with dating and model life table translation yielding trends [16]. Because siblings are close to the age of respondents, rather than a generation older, sibling survival data gives much more current estimates than data on survival of parents.

Results

Registered deaths during the 1982-1992 intercensal period are estimated to be 44.2 percent complete for females and 63.2 percent complete for males, relative to the 1982 census. The 1992 census is estimated to have enumerated females 2.6 percent more completely, and males 2.4 percent more completely, than the 1982 census. Substantial improvements in completeness of reporting are estimated to have occurred between 1982 and 1995 (Table 1, “Completeness”).

Age-specific death rates in prime adult ages rise by 200-300 percent between 1986 and 1997 (Table 1 and Figure 1). The conditional probabilities of death calculated from vital registration are remarkably consistent with those calculated from household deaths (solid plotting marks in Figures 2 and 3). Probabilities of death rise very sharply during the mid-1990s, with no indication of deceleration.

Conditional probabilities of death estimated from survival of survival of sisters and brothers (Table 2) are reasonably consistent with the vital registration estimates (Figure 2). They show a gradual net increase from the early 1980s to the early 1990s. The estimates based on survival of brothers do not confirm the decline between 1982 and 1986 indicated by the death registration estimates.

Conditional probabilities of death estimated from survival of mothers and fathers (Table 2) agree poorly with the other estimates, and the estimates from the 1992 census are in sharp disaccord with those from the 1997 survey (Figure 3). The estimates from the two censuses suggest a slow decline during the 1970s and 1980s. The estimates from the 1997 survey indicate rising mortality, especially in the mid-1990s.

Discussion

The various assumptions employed in the adjustment of registered deaths are of course open to various objections. Such assumptions are never perfectly satisfied, and the resulting estimates will therefore always err to some extent. The object is not perfection, however, but adjusted numbers that are substantially closer to the true numbers than the unadjusted numbers, and which are sufficiently accurate to be useful. Comparisons of the conditional probabilities of death derived from the adjusted death registration data with the other estimates leave no doubt that this has been achieved in the present application.

It might have been assumed that the true death rate age for age 10-14 declined, rather than remaining constant. The constant assumption results in a very rapid improvement in completeness of death registration, however, and assuming declining death rates would imply even more rapid improvement. It is therefore considered preferable to maintain the assumption that these rates were constant.

The consistency of the trend derived from registered deaths (adjusted for under reporting) and the trend derived from household deaths in the 1992 census and 1997 survey (unadjusted) is remarkably good. Since reporting errors in the household deaths data and errors in estimating changing registration completeness are largely independent, the consistency suggests that the estimated trend is approximately correct. It should be noted in this connection that the procedure for estimating the changing levels of completeness of death registration was worked out independently of the calculation of the estimates derived from the household deaths data, *i.e.*, the procedure was not varied to attain the consistency displayed in the figure.

The pattern of the increase in age-specific death rates between 1986 and 1995-1997 is as important as the magnitude (Figure 1). The normal age-pattern of human mortality, simply described, shows a sharp decline from infancy through late childhood, rises gradually through early middle age and sharply thereafter. In some cases there is a slight "bulge" at young adult ages. The sharp rise and fall of death rates observed for Zimbabwe between ages 20 and 60 departs is a radical departure from normal patterns and is indicative of unusually high young adult mortality. The relatively erratic age pattern of rates from the 1997 survey suggests that age-reporting in the survey is less accurate than age reporting on death certificates. The similarity of the magnitudes for females and males is notable.

The age-specific death probabilities reported in [17] are not comparable to the age-specific death rates in Table 1, but the magnitudes and age pattern are broadly comparable with the 1995 values in Table 1.

The conditional probabilities of death estimated from survival of siblings agree reasonably well with, but tend to be slightly higher than, the estimates from vital registration (Figure 2). The male and female estimates both confirm the rising trend despite minor erratic fluctuations. Death rates for the seven year period prior to the 1994 DHS survey derived from sibling histories are given in [18]. Interpolation and averaging death rates in Table 1 to give rates for the same period gives comparable rates. The rates given in [18] are about 20 percent lower than the corresponding rates derived from Table 1.

The conditional probabilities of death estimated from survival of parents are fractious (Figure 3). The fluctuations in the six different series (three data sources each for males and females) probably reflect errors and should be taken as giving, at most, a level and rate of decline estimated by robustly fitting a straight line. While the estimates from the 1982 and 1992 censuses are broadly consistent with each other as regards level and trend, they diverge sharply from both the death registration estimates and from the parental survival estimates from the 1997 survey.

The discrepancy between the 1992 census and 1997 survey parental survival estimates is particularly striking. The two series overlap for nearly a decade, during which the 1997 estimates greatly exceed the 1992 estimates and rise rather than fall. The difference in level between the two sets of estimates must be due in substantial part to differences in the quality of reporting of survivorship of parents in the 1992 census and the 1997 survey. Judging by comparison with the vital registration and household deaths estimates, survivorship was overstated in the census and understated in the survey. Essentially the same pattern is observed for males and females.

The internal inconsistency of the 1992 and 1997 parental survival estimates suggests that they should not be interpreted as casting doubt on the mortality trends estimated from the other three sources.

Considering the available evidence as a whole, it may be concluded that the death rates and probabilities derived from vital registration and household deaths (Table 1) may be taken as reasonably accurate estimates of the trend of adult mortality in Zimbabwe between 1982 and 1997. By way of summary, during the 15 year period 1982-1997 the conditional probability of survival to age 60 given survival to age 15, $_{45}q_{15}$, rises from 0.20 in 1982 to 0.50 for females and from 0.31 to 0.65 for males. The increase accelerates throughout this period. The pattern suggests that probabilities of death will rise further before leveling off and declining. How high is unclear, but if increases after 1997 followed a trend inversely symmetric to the increases before 1997—a plausible pattern—, the probability of death could rise to 0.8 or more.

There is essentially no doubt that these increases in adult mortality risks are due to HIV/AIDS. Given the timing, age pattern and magnitude of the changes, no competing explanation is remotely credible. The impact of AIDS as of 1997 may be taken as the difference between the mortality levels estimated for 1997 and 1986. This ignores the possibility that adult death rates might have declined in the absence of the epidemic, but also the possibility that they might have remained constant or even increased slightly for other reasons, *e.g.,* the strains imposed by structural adjustment policies [17]. Given the magnitude of the AIDS impact, however, the importance of other influences must be small to negligible.

The disparity between the 1992 and 1997 parental survival estimates show the danger of relying on any single source of data. The conclusions that could be drawn from this data alone would be far weaker than those possible when the other sources are utilized.

The poor performance of the parental survival estimates in this application should not be taken as evidence that they will perform similarly in other applications. Long experience with different data collection methods, questions and estimation procedures shows that there is great variability in performance. Methods that work poorly in one application may provide superior results in another.

When data collection is fraught with difficulty, as it nearly always is in developing countries, it is important to utilize all available sources of data. The chances of getting reliable estimates from any single source are often poor. Multiple sources often provide synergies that allow assessment of and correction for errors.

Vital registration data, in particular, should not be overlooked. Their obvious deficiency, under reporting of deaths, can often be corrected. Selection problems can be serious, but no more so than, for example, ante-natal clinic prevalence data. . Population censuses are available only at ten year intervals (rarely, at five year intervals). Surveys are expensive and generally cannot be afforded more than every 3-5 years, and even very large surveys yield small numbers of deaths. Vital registration, where available, provides large numbers of deaths, available annually or even monthly, data for many small geographic areas, and low marginal cost

Acknowledgements

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Table 1. Estimated age-specific death rates (ASDRs), probabilities of death ($_{35}q_{30}$ and $_{35}q_{15}$) and completeness of death registation (percent) for Zimbabwe, selected years, 1982-1995

	Based on vital registration adjusted for completeness of reporting						Based on household deaths	
	Year (midpoint)						Year (midpoint)	
Statistic	1982.5	1986.5	1990.5	1991.5	1992.5	1995.5	1992.6	1997.6
					Females			
ASDR 15-19	1.3	1.2	1.8	1.7	1.8	1.7	2.5	2.4
ASDR 20-24	1.9	1.9	2.9	3.3	4.0	5.9	4.5	5.1
ASDR 25-29	2.7	2.6	4.3	5.0	5.9	10.8	6.5	12.8
ASDR 30-34	3.1	3.1	5.0	5.4	7.3	14.3	6.6	20.3
ASDR 35-39	3.6	3.8	5.5	6.2	8.2	14.2	7.5	15.4
ASDR 40-44	4.9	5.5	6.7	7.7	8.9	14.0	8.1	23.1
ASDR 45-49	4.9	6.2	7.6	8.3	8.8	14.5	9.7	20.2
ASDR 50-54	9.9	8.8	9.9	9.3	9.6	10.9	10.2	15.6
ASDR 55-59	9.7	12.3	12.1	13.2	11.6	14.7	12.8	12.7
ASDR 60-64	18.1	17.8	20.2	19.6	19.2	19.0	18.2	16.3
35q15	107	117	159	177	208	331	210	421
45q15	195	210	252	270	292	417	301	503
35q30	249	263	300	311	324	422	322	494
Completeness	39.8	39.8	45.8	49.5	54.3	59.1	NA	NA
					Males			
ASDR 15-19	1.3	1.1	1.2	1.1	1.0	0.9	2.1	2.4
ASDR 20-24	3.2	2.0	2.5	2.6	2.9	3.4	4.1	5.2
ASDR 25-29	4.2	3.3	5.0	5.6	5.9	10.6	7.9	11.2
ASDR 30-34	4.9	4.6	7.5	8.4	9.6	16.2	10.6	29.0
ASDR 35-39	5.3	4.9	8.4	9.9	11.6	21.5	11.4	23.4
ASDR 40-44	7.7	6.5	9.4	10.5	12.4	22.9	13.0	24.3
ASDR 45-49	9.3	9.2	11.0	11.7	13.2	21.3	14.4	25.2
ASDR 50-54	17.0	13.5	15.4	15.5	17.5	22.1	15.7	28.2
ASDR 55-59	16.9	20.6	21.4	20.6	19.8	25.5	19.4	33.7
ASDR 60-64	30.0	26.2	27.6	27.2	30.1	28.9	25.3	37.7
35q15	169	150	209	230	259	414	285	496
45q15	310	295	355	369	397	553	411	651
35q30	395	374	426	435	469	593	452	695
Completeness	57.1	57.1	65.7	71.0	77.9	84.9	NA	NA

Note: Rates from vital registration calculated for all available years. See text for explanation of procedure for adjusting for incomplete reporting. Household deaths are as reported (no adjustment) in the 1992 population census and the 1997 national population survey.

Table 2. Male and female probabilities of death $_{35}q_{30}$ and $_{35}q_{15}$ estimated from survival of fathers, mothers, sisters and brothers: Zimbabwe, 1982 and 1992 census, 1997 intercensal survey and 1994 Demographic and Health Survey (DHS)

Females

	Survival of mothers						Survival of sisters	
	1982 Census		1992 Census		1997 ICS		1994 DHS	
	Time	$_{35}q_{30}$	Time	$_{35}q_{30}$	Time	$_{35}q_{30}$	Time	$_{35}q_{15}$
	1969.3	216	1979.9	184	1982.8	292	1981.8	109
	1969.0	253	1979.6	208	1983.3	309	1983.3	138
	1969.6	258	1980.0	206	1983.9	331	1985.1	124
	1970.5	250	1980.7	216	1985.0	335	1987.0	143
	1971.7	239	1981.7	219	1986.3	331	1989.2	180
	1973.1	219	1983.1	215	1987.9	339	1991.4	207
	1974.9	184	1984.9	195	1989.7	339		
	1977.0	173	1987.0	174	1991.8	389		
	1979.2	184	1989.2	176	1994.2	428		
Median	1971.7	219	1981.7	206	1986.3	335	1986.1	140
	1982-92			1992-97				
	1987.6	191		1995.1	511			

Males

	Survival of fathers						Survival of brothers	
	1982 Census		1992 Census		1997 ICS		1994 DHS	
	Time	$_{35}q_{30}$	Time	$_{35}q_{30}$	Time	$_{35}q_{30}$	Time	$_{35}q_{15}$
	1969.8	408	1980.3	331	1984.2	423	1981.6	156
	1970.4	418	1980.7	335	1984.9	426	1983.2	149
	1971.3	418	1981.5	341	1985.9	431	1985.0	165
	1972.6	404	1982.6	341	1987.2	435	1987.0	172
	1974.1	362	1984.1	328	1988.8	436	1989.1	207
	1975.8	355	1985.8	278	1990.6	489	1991.4	230
	1977.7	428	1987.8	307	1992.6	555		
Median	1972.6	408	1982.6	331	1987.2	435	1986.0	169
	1982-92			1992-97				
	1987.6	259		1995.1	549			

Note: $_{35}q_{30}$ denotes conditional probability of death by age 65 given survival to age 30. $_{35}q_{15}$ denotes conditional probability of survival to age 50 given survival to age 15. See text for explanation of estimation procedures.

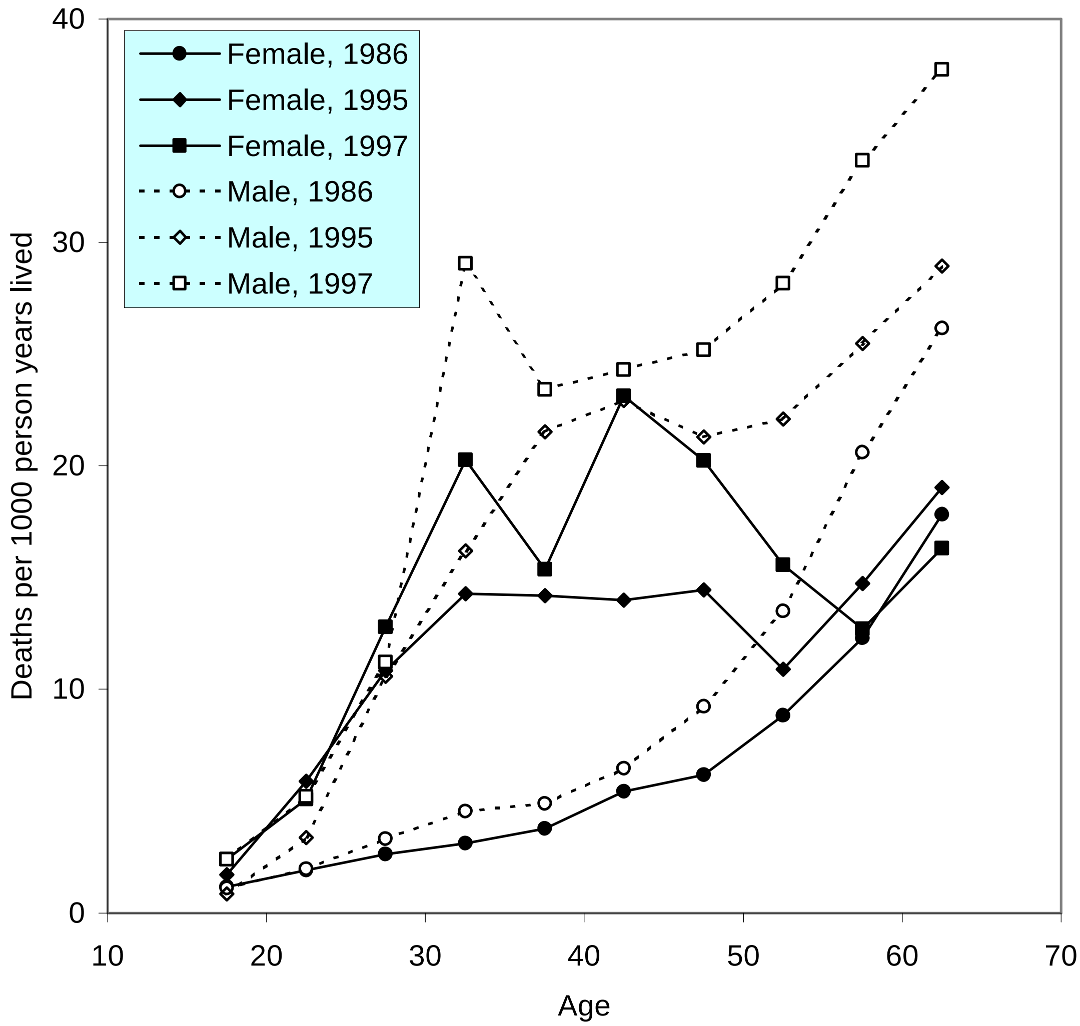

Fig. 1. Age-specific death rates, by sex, Zimbabwe, selected years. Rates for 1986 and 1995 are calculated from vital registration data corrected for under-reporting. Rates for 1997 from 1997 population survey, unadjusted. See text for explanation of vital registration correction procedure.

Source: Table 1.

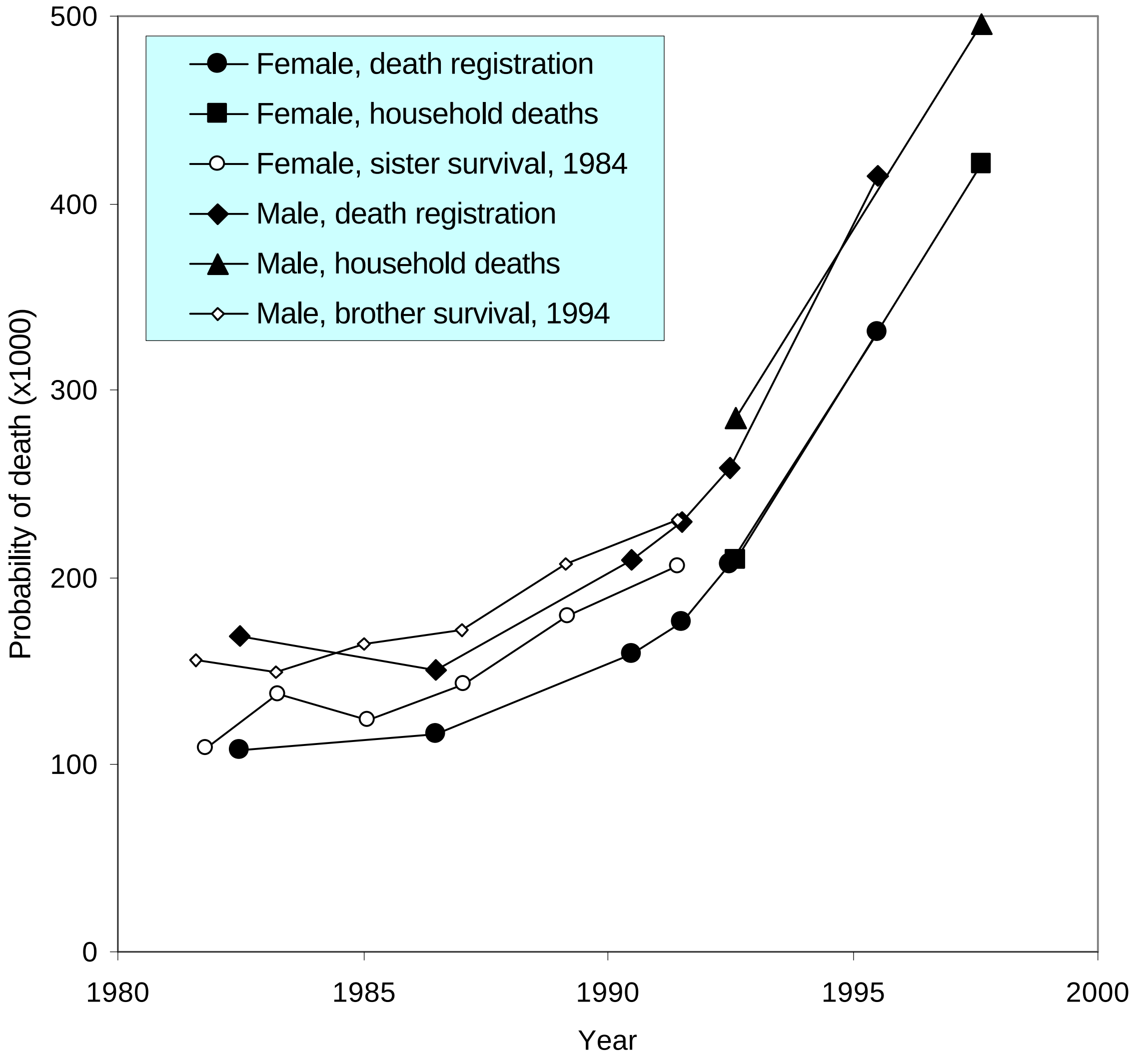

Fig 2. Conditional probability of surviving to age 50 given survival to age 15, ($_{35}q_{15}$) by sex, estimates from various sources, Zimbabwe, 1982-1997.

Source: Tables 1 and 2.

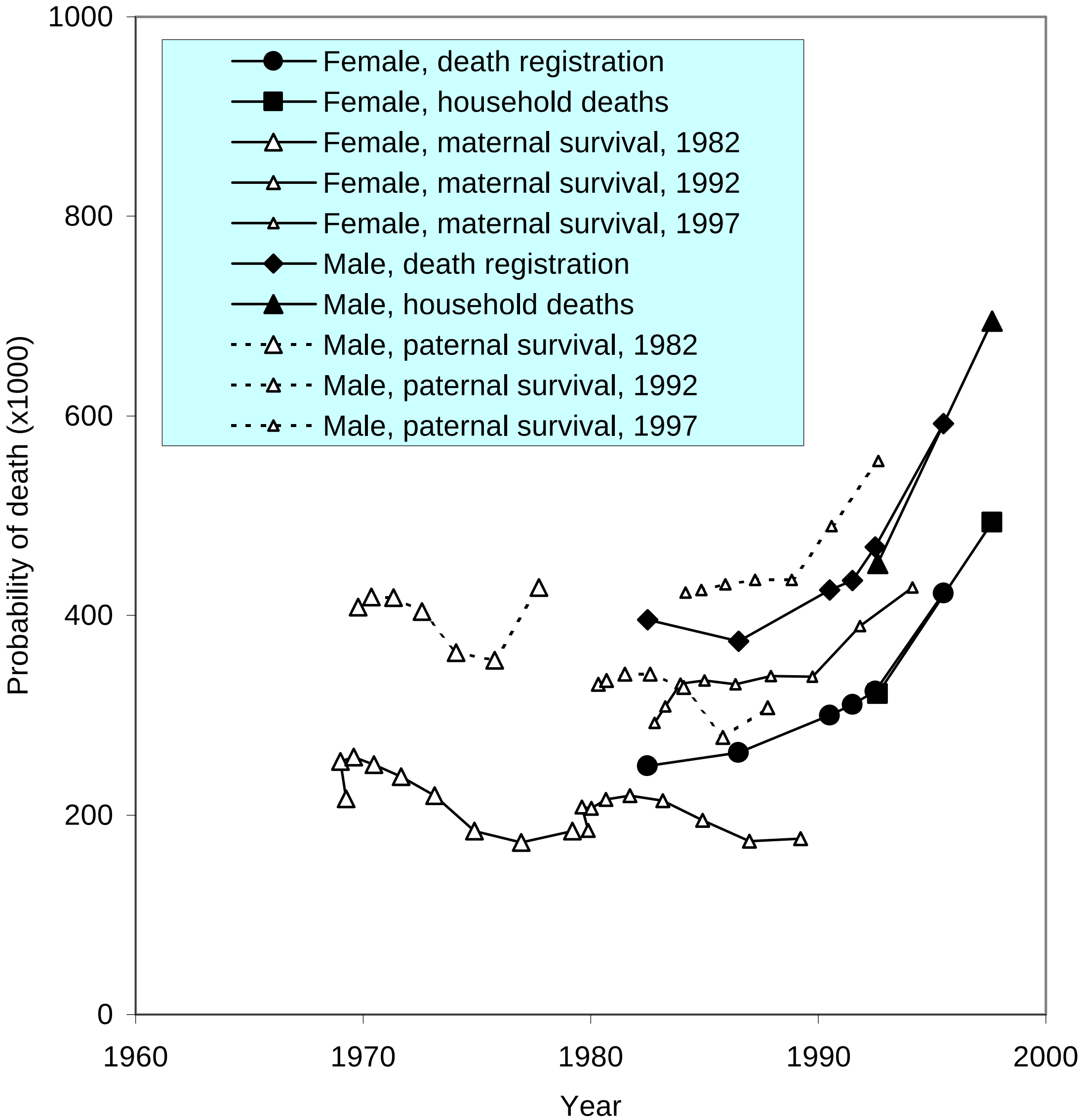

Fig. 3. Conditional probability of surviving to age 65 given survival to age 30 (35q30), by sex, estimates from various sources, Zimbabwe, 1969-1997.

Source: Tables 1 and 2.