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HIV decline in Zimbabwe due to reductions in risky sex? Evidence from a comprehensive epidemiological review

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Background Recent data from antenatal clinic (ANC) surveillance and general population surveys suggest substantial declines in human immunodeficiency virus (HIV) prevalence in Zimbabwe. We assessed the contributions of rising mortality, falling HIV incidence and sexual behaviour change to the decline in HIV prevalence.

Methods Comprehensive review and secondary analysis of national and local sources on trends in HIV prevalence, HIV incidence, mortality and sexual behaviour covering the period 1985–2007.

Results HIV prevalence fell in Zimbabwe over the past decade (national estimates: from 29.3% in 1997 to 15.6% in 2007). National census and survey estimates, vital registration data from Harare and Bulawayo, and prospective local population survey data from eastern Zimbabwe showed substantial rises in mortality during the 1990s levelling off after 2000. Direct estimates of HIV incidence in male factory workers and women attending pre- and post-natal clinics, trends in HIV prevalence in 15–24-year-olds, and back-calculation estimates based on the vital registration data from Harare indicated that HIV incidence may have peaked in the early 1990s and fallen during the 1990s. Household survey data showed reductions in numbers reporting casual partners from the late 1990s and high condom use in non-regular partnerships between 1998 and 2007.

Conclusions These findings provide the first convincing evidence of an HIV decline accelerated by changes in sexual behaviour in a southern African country. However, in 2007, one in every seven adults in Zimbabwe was still infected with a life-threatening virus and mortality rates remained at crisis level.

Keywords Zimbabwe, HIV decline, HIV incidence, mortality, behaviour change

Introduction

Zimbabwe lies in southern Africa, the current epicentre of the global acquired immunodeficiency syndrome (AIDS) pandemic.[1] The first cases of AIDS were identified in the mid-1980s[2] and by 1990—the first year of antenatal clinic (ANC)-based surveillance—human immunodeficiency virus (HIV) prevalence exceeded 10%. The country's national estimate for HIV prevalence amongst adults in 2007 was 15.6% (range 14.9–16.3%).[3] In part, the scale of the epidemic at country level reflects its widely disseminated nature. HIV prevalence in small towns, farming estates and mines located in rural areas (22%) exceeds that in the major cities (14.5%), and prevalence is high even in subsistence farming areas (14.5%).

Recent data from ANC surveillance[4] and general population surveys[5] suggest that Zimbabwe was the first country in the southern African region to record convincing declines in HIV prevalence. A national decline in HIV prevalence is intrinsically a positive and important development because it represents a reduction in the burden of infection within the population. If maintained, it should translate into lower mortality over the next 5–10 years. However, declines in HIV incidence (new infections) and prevalence (existing infections) can occur through the natural dynamics of an epidemic.[6] This is because, once the infection saturates and ages within the most vulnerable groups, the rate of transmission within the population as a whole tends to slow and can fall below the point where numbers of AIDS deaths exceed numbers of new infections. Declines in HIV prevalence (and even declines in HIV incidence) are therefore not a sufficient indication of sexual behaviour change affecting the course of the epidemic.

Programmatically, it is important to know whether changes in sexual behaviour contributed to the declines in HIV prevalence. We carried out a comprehensive review of the epidemiological data for Zimbabwe (i) to confirm the existence of a decline in HIV prevalence, (ii) to establish the contributions of falling HIV incidence and rising mortality to the fall in HIV prevalence and (iii) to assess whether changes in sexual behaviour contributed to the declines in HIV infection.

Methods

Review process

A review of epidemiological and behavioural data from secondary sources was carried out between November 2004 and June 2005. Formal request letters were sent to all organizations considered potential sources of surveillance data and follow-up inquiries were made by e-mail and telephone. Meetings were held with the organizations concerned to identify relevant data. The review was conducted by the authors with guidance from participants in meetings of the The Joint United Nations Programme on HIV/AIDS (UNAIDS) Reference Group on Estimates, Modelling and Projections meeting (16 November 2004) and local stakeholders (7 June 2005 and 30 May 2008).

Data sources and data evaluation procedures

Details of the principal data sources reviewed are given in Table 1. The data were evaluated for quality and potential bias by examining the study designs and methods of data collection employed (including sample sizes and response and follow-up rates) and the appropriateness and consistency of methods of measurement used for individual indicators within and across studies.[7] Reference was made, where possible, to in-depth studies of bias in the specific data sources.[8–11] The plausibility of the data was considered together with their external and internal consistency—including secondary analysis and triangulation of estimates from different sources and for related indicators.

Data on trends in HIV prevalence amongst pregnant women were obtained from the national ANC surveillance system for the period 2000–06[4,12] and were complemented by data from in-depth studies in urban (Harare, 1991–2002)[13–15] and rural areas (Manicaland, 1998–2005).[5] A point estimate for HIV prevalence amongst the general population nationally in 2005 was obtained from the Zimbabwe Demographic and Health Survey (ZDHS) 2005.[16] No longitudinal data were available on national trends in the general population but data from community studies in Manicaland, Zimbabwe's eastern province, were examined.[5] Data on trends in HIV prevalence were also extracted from routine records maintained by the Zimbabwe National Blood Transfusion Service (1992–2004), voluntary counselling and testing centres (2000–04) and the national prevention of mother-to-child transmission of HIV programme (2002–04). However, trends in these data were distorted by bias associated with the introduction, scale-up and selection criteria of these programmes[7], hence the detailed results are not presented here.

To assess trends in HIV incidence in the national and rural populations, we examined trends in data on HIV prevalence in young adults.[4,5] For urban populations, we compared estimates from prospective cohort studies of previously uninfected post-natal women (1999[14] vs 1992[17]) and male factory workers (2002–03[18] vs 1994–95)[19]. Estimates for levels and trends in adult mortality were obtained from reports of deaths in the household and brother and sister (sibling) survival made in national censuses[20–22] and surveys,[9,23] from vital registration records for the cities of Harare and Bulawayo,[24] and from population cohort data for rural areas in Manicaland.[25]

The possible contribution of selective international migration of HIV-positive individuals to changes in national levels of HIV prevalence was assessed using United Kingdom Health Protection Agency data on

Table 1 Data sources reviewed providing data on trends in HIV prevalence and components of change in HIV prevalence

Data source	Type of data	Population	Methods of recruitment and data collection	Time period covered	Response rate (%)	Limitations
HIV prevalence						
National antenatal clinic surveillance surveys[12]	Serial cross-sectional	Pregnant women at 19 purposively selected sentinel sites	Unlinked anonymous sero-surveys using blood samples drawn for routine syphilis testing	1990–2006	100	Selection bias — data on pregnant women provide only indirect evidence for trends in the general population (including men); sentinel sites may not be nationally representative.[a] Data collected prior to 2000 are not directly comparable (e.g. different clinics and diagnostic test algorithms were used)
Local antenatal clinic surveillance surveys[5,13–15]	Serial cross-sectional	Pregnant women at selected sites	Unlinked anonymous sero-surveys using blood samples drawn for routine syphilis testing	1990–2005	100	Selection bias arising from use of data on pregnant women attending for ante-natal care from selected sites
Manicaland study[5,8]	Prospective open cohort	Adults (17–44 years) in four socio-economic strata in Manicaland province	Eligible individuals identified through prospective household census	1998–2005	79–83	Trends in the Manicaland sites may not be representative of the whole country
Zimbabwe National Blood Transfusion Service[7]	Longitudinal	Blood donors	Routine service data	1992–2004	100	Selection bias—potential donors screened for known risk factors for HIV infection
Population Services International voluntary counselling and testing (VCT) centres[7]	Longitudinal	VCT clients at selected sites	Routine service data from 20 VCT centres[b]	2000–04	100	Selection bias—VCT clients are disproportionately ill and may have other characteristics associated with HIV risk; bias changed over time as ART services were scaled-up
National prevention of mother-to-child transmission (PMTCT) programme records[7]	Longitudinal	PMTCT clients at selected sites	Routine service data	2002–04	100	Selection bias arising from use of data on pregnant women attending for ante-natal care at clinics offering PMTCT services; bias changed over time as the spatial coverage of the PMTCT programme increased
HIV incidence						
Research studies on ante- and post-natal women[14,17]	Prospective cohort	Ante- and post-natal women, Harare	Prospective follow-up of women offered VCT during pregnancy	1992 vs 1999	Unknown 78 (12 m)	Selection bias—trends in ante- and post-natal women in Harare may not be representative of those occurring in the national population
Research studies on male factory workers[18,19]	Prospective cohort	Male factory workers, Harare	Prospective follow-up of men offered VCT and	1994–95 vs 2002–03	81 (6 m) 69 (24 m)	Selection bias—trends in male factory workers in Harare may not be

(continued)

Table 1 Continued

Data source	Type of data	Population	Methods of recruitment and data collection	Time period covered	Response rate (%)	Limitations
			free condoms at their workplaces			representative of those occurring in the national population
Zimbabwe National Blood Transfusion Service records[7]	Longitudinal	Blood donors (repeat testers)	Window period[c] estimates derived from routine service data	1995–2003	100	Small numbers of repeat testers; unvalidated method for identifying window period cases
Mortality						
Zimbabwe National censuses, 1982, 1992 and 2002[20–22]	Serial cross-sectional	Adults (15–60 years) in the general population	National household census	1980–2004	Males, 92; females, 84 (9)	Coverage assumed to be uniform for all ages in a census.[d] Assumptions made on migration over the intercensal period. Requires estimate of the population 1 year before each census.[e] Omission of deaths due to selective dissolution of households with adult deaths
Zimbabwe Demographic and Health Surveys, 1988, 1994, 1999 and 2005–06[16,27–29]	Serial cross-sectional	Adults (15–60 years) in the general population	Sibling survival histories collected in nationally representative household survey	1988–99	86–96	Respondents may not know the survival status of some of their siblings
Vital registration systems[7,24]	Longitudinal	General population Harare and Bulawayo	Information from death certificates captured in vital registration records	1980–2004	Males, 85; females, 59 (10)	Incomplete coverage and urban–rural migration prior to death—in each case, levels may have increased over time.[f] Burial records used in Bulawayo from 2003
Manicaland study[25]	Prospective open cohort	Adults (17–44 years) in four socio-economic strata in Manicaland province	Follow-up of individuals interviewed in three successive rounds of a household survey	1998–2005	61–63[g]	Trends in the Manicaland sites may not be representative of the whole country. Death rates in subjects lost to follow-up may differ from those reported on in later rounds
Sexual behaviour						
Zimbabwe Demographic and Health Surveys, 1988, 1994, 1999 and 2005–06[16,27–29]	Serial cross-sectional	Adults (15–49 years) in the general population	Nationally representative household survey with two-stage sampling design: (i) EAs selected with probability proportionate to size; and (ii) households in EAs selected at random	1988–99	86–96	Social desirability bias—possibly changing over time. Recall bias for behaviours reported over longer time periods. Changes in the indicators used in successive surveys
Population Services International knowledge, attitudes, beliefs and	Serial cross-sectional	Youth and young adults (15–29 years)	As for ZDHS	1997–2007	96–98	Inconsistencies in sampling, questionnaire design and field procedures between survey rounds. Limited age-range

(continued)

Table 1 Continued

Data source	Type of data	Population	Methods of recruitment and data collection	Time period covered	Response rate (%)	Limitations
practices surveys, 1997, 1999, 2001, 2003, 2005–07[30]						(15–29 years). Social desirability and recall bias
Zimbabwe Young Adult Survey, 2001–02[32]	Cross-sectional	Youth and young adults (15–29 years)	As for ZDHS	2001–02	85	Limited age range (15–29 years). Social desirability and recall bias
National OVC Baseline Survey, 2004–05[33]	Cross-sectional	Youth and young adults (12–24 years)	National household survey with two-stage purposive sampling of districts and census EAs	2004–05	NA[h]	Survey districts and enumeration areas purposively selected—poorer areas oversampled. Limited age range (12–24 years). Social desirability and recall bias
Manicaland study[5]	Prospective open cohort	Adults (17–44 years) in four socio-economic strata in Manicaland province	Eligible individuals identified in prospective household census and followed up in subsequent rounds. ICVI[i] to reduce social desirability bias	1998–2003	61[g]	Trends in the Manicaland sites may not be representative of the whole country. Social desirability and recall bias

[a]A recent analysis comparing HIV prevalence estimates for 2006 from the national ANC surveillance sites to estimates from the matched clusters in the 2005–06 Zimbabwe Demographic and Health Survey shows good agreement between the ANC estimate and HIV prevalence amongst men and women combined in the general population.
[b]Eight centres provided data each year from 2002 to 2004.
[c]Cases of early HIV infection not identified when clients first present for testing because the level of antibodies is below the threshold detectable by the HIV assays employed but detected when these clients present for repeat testing 3 months later.
[d]The estimation method applied corrects for changes in coverage over time.[9]
[e]Alternatively, estimates of number of deaths in the intercensal period from deaths in the year before each census can be used.
[f]The completeness estimates shown here are for Zimbabwe as a whole in 1995. Feeney estimates that completeness increased from 57 and 40% in 1982 to 85 and 59% in 1995 for males and females, respectively.[10]
[g]Follow-up rate between survey rounds conducted at 2–3 year intervals.
[h]Households added until required numbers of eligible children had been enumerated.
[i]Informal confidential voting interviews.[11]
NA: Not available, EA: enumeration area, OVC: Orphans and vulnerable children.

trends in Zimbabwe-born women tested at delivery at clinics in London (except south-west London) and the south-east and north-west regions of the UK between 2000 and 2006.

HIV in adults in Zimbabwe is acquired predominantly through heterosexual transmission.[11,26] Evidence for changes in sexual behaviour was assessed using data from the ZDHS surveys 1988,[27] 1994,[28] 1999[29] and 2005,[16] a series of bi-annual knowledge, attitudes, practices and beliefs surveys commissioned by Population Services International (PSI) between 1997 and 2007,[30] the National Youth Reproductive Health Survey (ZNFPC) 1997,[31] the Zimbabwe Young Adult Survey 2001–02[32] and the National OVC Baseline Survey 2004.[33] Data on trends in behaviour in a general population cohort of 10 000 adults in Manicaland were also examined.[5,11]

Statistical analysis

Estimates of HIV prevalence and incidence with 95% exact binomial confidence limits were calculated and compared using data from the sources described above.

Adult mortality rates were estimated for the period 1992–2002 from deaths reported by households in the 1992 and 2002 censuses. The method is described in detail elsewhere[9] but, essentially, the rates were calculated directly after adjusting the data on population size and deaths for bias in completeness of reporting. The results were compared with estimates from sibling data.[23] Crude death rates were calculated from local vital registration data.[24]

There being no data on the extent of migration of HIV-infected persons from Zimbabwe, we investigated the potential impact of international out-migration on recent trends in HIV prevalence by fitting a published mathematical model[34] to the data on sexual behaviour (see below). Projections were made and compared under the assumptions of no intentional behaviour change and: (i) no migration; (ii) linear increase in migration from 0 to 5% of the total population per annum, 1997–2000, followed by constant 5% migration per annum; (iii) linear increase in migration from 0 to 10% of the total population per annum, 1997–2000, followed by constant 10% migration per annum; (iv) as for (iii) except that HIV-positive persons with symptomatic infection (AIDS) were 20 times more likely to migrate than uninfected individuals; (v) as for (iv) except that non-symptomatic HIV-positive individuals were also 20% more likely to migrate than uninfected individuals.

Indicators of the three main potential forms of sexual behaviour change (namely primary sexual abstinence, sexual partner acquisition and condom use) were calculated and compared for the national surveys listed above, for each sex separately. For evidence of change in sexual abstinence, median age at first sex (with inter-quartile range) amongst 15–24-year olds was calculated using a standard survival analysis technique.[35] For evidence of change in sexual partner acquisition rates, the proportion of sexually-experienced 15–29-year olds reporting one or more non-regular sexual partner in the past 12 months was examined. For this analysis, a non-regular sexual partner was defined as a non-marital, non-cohabiting sexual partner. For evidence of change in condom use, the proportion of 15–29-year olds with a non-regular partner in the past 12 months who reported having used a condom at last sexual intercourse with such a partner was examined. The age ranges 15–24 years and 15–29 years were used in the analyses so as to maximize the numbers of data sources included in the comparisons. To assess recent trends over a wider age range, longitudinal data from the Manicaland study were examined.

Results

HIV prevalence

National antenatal HIV surveillance began in Zimbabwe in 1990. Initially, the selection of sites changed from year to year and few details are accessible on the field and laboratory methods used. For some sites, large fluctuations were observed between successive rounds of surveillance. However, it appears that HIV prevalence increased steadily in the early to mid-1990s and stabilized in the late 1990s.[7] HIV surveillance was strengthened in 2000 with an expansion in coverage, particularly in rural settings, more consistent site selection and field procedures and detailed documentation of the procedures used.[4] A Genscreen test was used for HIV testing in 2000. Subsequent evaluations of this test showed a low specificity under field conditions in Zimbabwe leading to over-estimates of HIV prevalence. Therefore, a new combined test algorithm was adopted from 2002.[4]

Based on results from the Genscreen test, HIV prevalence declined in 15- 49-year-old pregnant women from 32 to 24% over the period 2000–04 [Cochran-Armitage Trend Test, $Z = 10.6599$, P-value (one-sided) <0.0001] (Figure 1a).[12] Based on the combined test algorithm, HIV prevalence declined from 26% in 2002 to 18% in 2006. HIV prevalence fell in consecutive surveys in all age groups up to age 40 years (Figure 1b). Median HIV prevalence for the 19 sentinel sites was 25% in 2002, 20.5% in 2004 and 17% in 2006 (UNAIDS fixed effects model for trend, $P < 0.0001$). HIV prevalence in antenatal attendees fell between 2002 and 2006 in each of the three main socio-economic strata—from 26.5 to 17% in urban areas, from 29 to 24% in other centres of commercial activity and from 22 to 15% in rural areas.[12] In the 12 surveillance sites that were used consistently from 1997,[36] median HIV prevalence in 15–44-year-olds rose from 24% [interquartile range (IQR) 23–40%] in 1997 to 33.5% (29–39%) in 2000

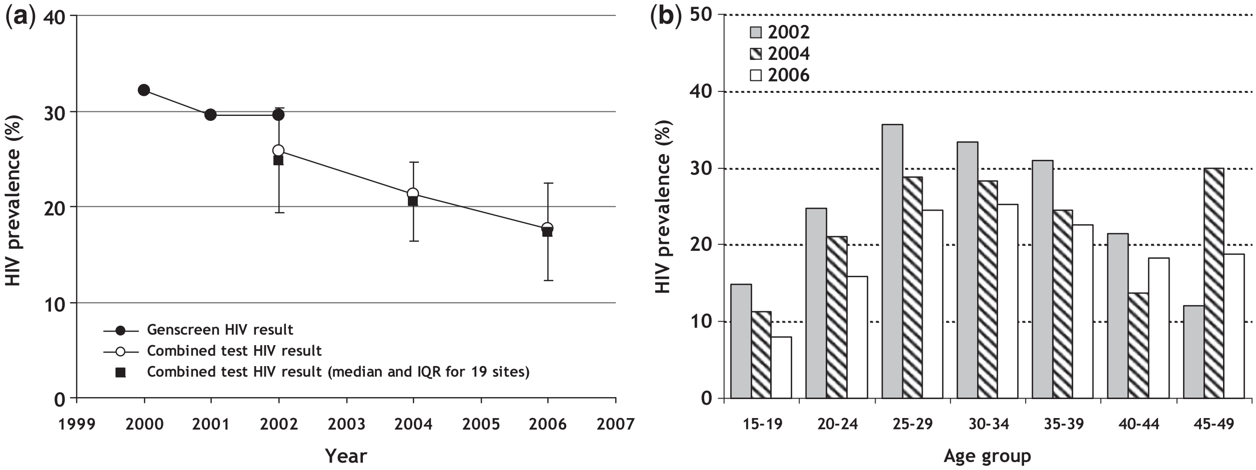

Figure 1 Decline in HIV prevalence in pregnant women attending for routine check-ups at 19 ANCs, Zimbabwe, 2000–06. (a) Women aged 15–49 years; and (b) by 5-year age groups, 2002–2006 (using combined test). *Source*: Zimbabwe Ministry of Health and Child Welfare ANC Surveillance Reports[12]

before falling to 28% (23–35%) in 2002, 22.5% (19–28%) in 2004 and 20% (19–26%) in 2006.[7]

In greater Harare, HIV prevalence in women attending antenatal and maternity clinics increased from 17% in 1991 to ~35% in 1999 before falling to 19.5% in 2004.[4,14] In rural Manicaland, there was a reduction in HIV prevalence in ANC attendees from 21% [95% confidence interval (CI) 19–24%] in 1998–2000 to 15% (13–17%) in 2003–05, whereas, in the general population, HIV prevalence fell in men from 19.5% (18.5–21%) to 16.5% (15.5–17.5%) and in women from 26% (25–27.5%) to 20.5% (19.5–21.5%).[5]

Based on the antenatal surveillance data for urban, rural and other areas and census data on the national population distribution, the 2005 national estimates for Zimbabwe put HIV prevalence in adults in 2005 at 20.1% (range 17–23.5%).[37] The ZDHS estimate for 2005 was slightly lower at 18.1% (95% CI 17.4–18.8%).[16] Using this point estimate and the ANC surveillance data, the 2007 national estimates report indicated that HIV prevalence had declined to 15.6% in 2007 (range 14.9–16.3%) from a peak of 29.3% in 1997.[3]

HIV incidence

HIV incidence measured in cohorts of pregnant women and male factory workers in Harare fell from 4.8 per 100 person-years at risk (%) (95% CI 3.1–6.5%) in 1992[17] to 3.4% (3.0–3.8%) in 1999[14] and from 3.0% (2.5–3.5%) in 1994–95[19] to 1.3% (1.0–1.8%)[18] in 2002–03, respectively (Figure 2a).[7] There were differences in the age composition of the study populations used in these comparisons. However, declines in HIV incidence in most age groups were observed in both studies[7] and the decline in male factory workers was still observed after adjusting for age [age-adjusted incident rate ratio (IRR) 0.50, 95% CI 0.36–0.70%].

HIV prevalence among young people aged 15–24 years can provide useful indications of trends in HIV incidence.[38] Nationally, HIV prevalence in 15–24-year-old women attending ANCs fell from 30% in 2000 to 20% in 2004 (using the Genscreen test) and from 21% in 2002 to 13% in 2006 (using the combined test algorithm) (Figure 2b). Declines occurred between 2002 and 2006 in all socio-economic locations (urban, rural and other). In the Manicaland study, HIV prevalence in the general population fell between 1998 and 2003 from 5.4% (95% CI 4.5–6.5%) to 3.3% (2.6–4.1%) in men aged 17–24 years and from 16.5% (14.9–18.1%) to 8.8% (7.9–9.7%) in women aged 15–24 years.[5]

Applying back-calculation methods to data on registered deaths in Harare (see below), Lopman and Gregson[39] found that HIV incidence in Harare may have peaked between 1988 and 1990.

Mortality

Mortality began to rise in urban areas of Zimbabwe in the late 1980s[40] and in rural areas in the early to mid-1990s.[41] National estimates from sibling survival histories collected in Demographic and Health surveys indicate that the probability of death before age 60 years among those who survive to age 15 years increased from 30 and 21%, for men and women, respectively, in the late 1980s to ~70% for men and 60% for women, by the early 2000s (Figure 3a).[16,23] The estimates of mortality based on the census data are somewhat higher but again indicate a rapid and substantial rise in adult mortality during the 1990s.

In Harare, the crude death rate, estimated from vital registration data, also rose rapidly during the 1990s (Figure 3b). The subsequent stabilization and reduction may reflect increased urban–rural and international migration associated with the economic decline that occurred from the late 1990s.

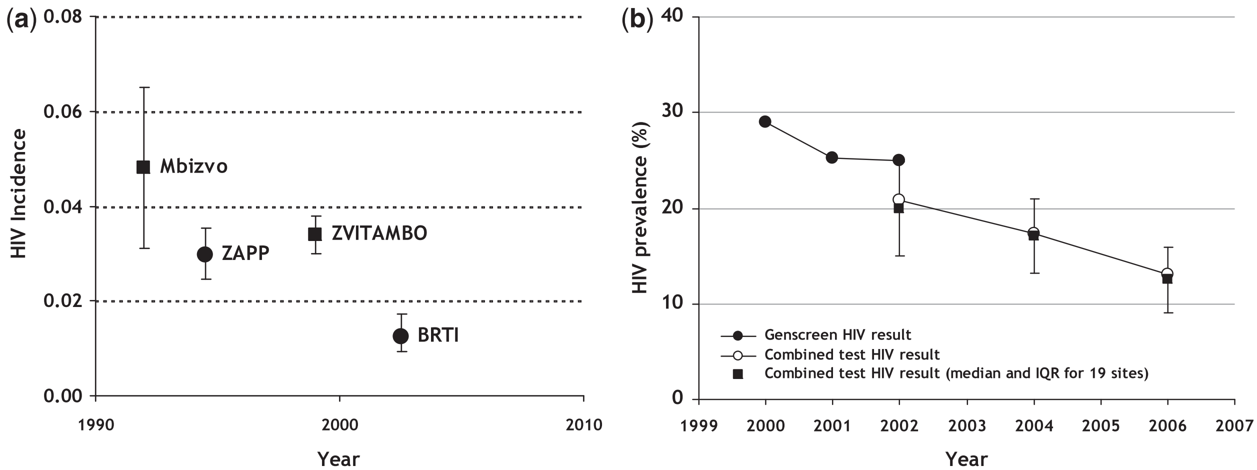

Figure 2 Decline in HIV incidence, Zimbabwe, 1990–2006. (a) HIV incidence measured in cohorts of ante- and post-natal women (filled squares: *Sources:* Mbizvo;[17] ZVITAMBO[14]) and male factory workers (filled circles: *Sources:* ZAPP;[19] BRTI[18]), Harare; and (b) HIV prevalence in pregnant women attending for routine check-ups at ANCs, 15–24 years, 2000–06[12]

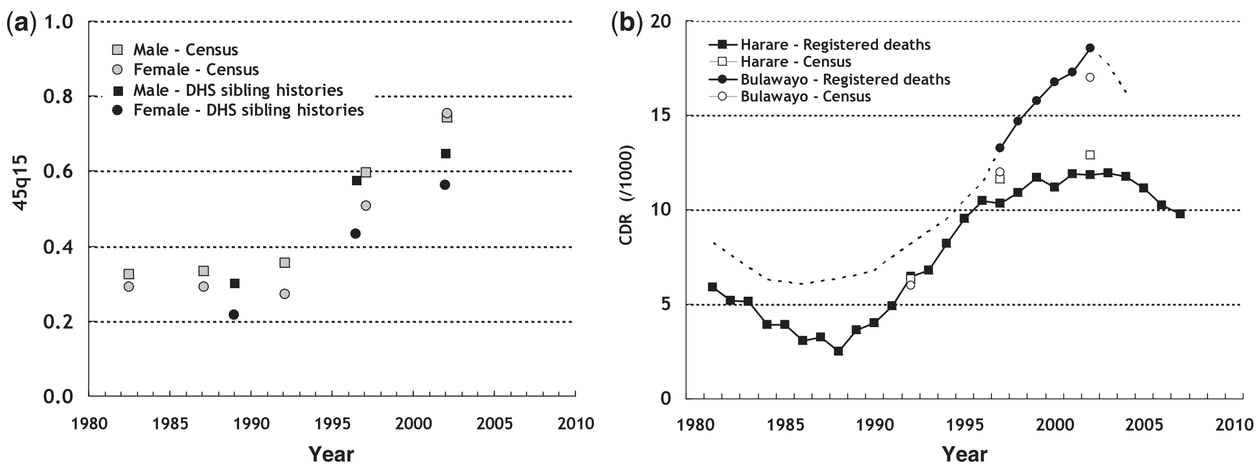

Figure 3 Increase in mortality, Zimbabwe. (**a**) Probability of death between ages 15 and 60 years ($_{45}q_{15}$) estimated from sibling survival histories collected in the Zimbabwe Demographic and Health Surveys (DHS), 1988–2005/06[16,27–29] and from household data collected in national censuses 1982, 1992, 1997 and 2002;[20–22] and (**b**) crude death rate, Harare and Bulawayo, estimated from vital registration data on numbers of deaths per annum and census estimates of population numbers, 1980–2004.[24] For Bulawayo, the estimates (shown by the dashed lines) for 1981 to 1991 were read from a figure in the Bulawayo City Health Report 1992; for 2003 and 2004, the estimates were derived from burial records rather than records of registered deaths

In Bulawayo, the crude death rate continued to rise up to 2002. The subsequent trend is unclear due to a switch to the use of burial records. The levels of the vital registration mortality estimates are consistent with those derived from the census. In rural Manicaland, male and female adult mortality levelled off at around 30 deaths per thousand person-years between 2001 and 2005, following earlier increases.[25]

International migration

Migration of Zimbabweans to the Diaspora has been extensive since the late 1990s and selective out-migration of HIV-positive individuals could have contributed to the decline in HIV prevalence. However, the results of the mathematical model simulations suggest that, even with very large numbers of migrants, this effect can only have been small unless extreme assumptions are made. For example, the final scenario shown in Figure 4a (long dashed lines) reflects a situation in which, as the epidemic peaks, 10% of the national population migrates every year, with persons with AIDS 20 times more likely to migrate than uninfected individuals, and with 10% of asymptomatic HIV-positive individuals aware of their status and three times as likely to migrate as uninfected individuals.

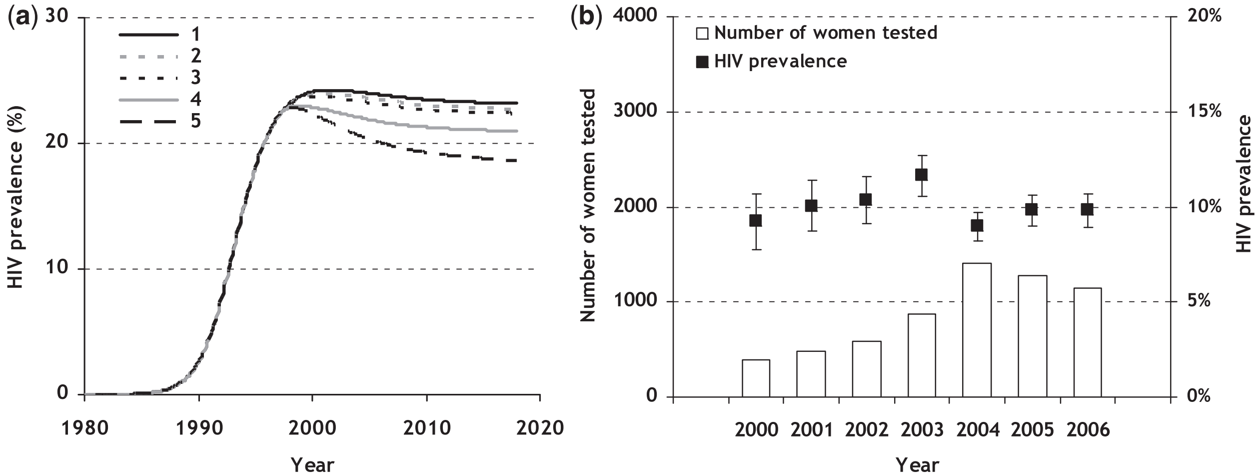

Figure 4 Migration and HIV prevalence decline. (**a**) Mathematical model projections of the potential impact of international out-migration on trends in HIV prevalence in Zimbabwe: (1) no migration; (2) linear increase in migration from 0–5% of the total population per annum, 1997–2000, followed by constant 5% migration per annum; (3) linear increase in migration from 0 to 10% of the total population per annum, 1997–2000, followed by constant 10% migration per annum; (4) as for (3) except that HIV-positive persons with symptomatic infection (AIDS) are 20 times more likely to migrate than uninfected individuals; (5) as for (4) except that non-symptomatic HIV-positive individuals are also (on average) 20% more likely to migrate than uninfected individuals. All scenarios assume no intentional behaviour change. (**b**) HIV prevalence in Zimbabwe-born women at delivery in the UK, 2000–2006 (*Source:* UK Health Protection Agency). Includes women tested in London (except South-West London), and the South-East and North-West regions of the UK (95% CIs)

There are two main destinations of recent migrants from Zimbabwe: the UK, Australasia and other western countries; and South Africa, Botswana and other neighbouring countries in southern and central Africa. There are no reliable estimates of numbers of migrants to either of these destinations since 2000. Numbers of Zimbabwe-born women tested at ANCs in the UK increased between 2000 and 2004 and fell slightly thereafter but HIV prevalence in these women remained stable at ~9–11% (Figure 4b), which suggests that HIV prevalence in Zimbabweans migrating to western countries could be lower than amongst non-migrants. Migrants to southern and central African countries may have a different socio-economic profile due to the shorter distances and greater possibilities for unauthorised border crossings. However, data from Manicaland suggest that, within Zimbabwe at least, rural out-migrants have similar socio-economic characteristics and vulnerability to HIV/AIDS prior to migrating to non-migrants.[42]

Sexual behaviour change

Consistent estimates of median age at first sex were available from 11 different national surveys covering the period 1994–2007 for men and 12 surveys covering 1988–2007 for women. In both cases, median age at first sex fluctuated within the range 17–20 years with no clear evidence for a trend over time (Figure 5a). In the ZDHS surveys, the proportion of males aged 15–19 years who reported having ever had sex fell from 33% in 1994 to 27% in 2005 ($P = 0.005$), whereas there was no change in this proportion amongst females. In Manicaland, the proportions of males aged 17–19 years and females aged 15–17 years who reported having ever had sex fell from 45 to 27% ($P < 0.001$) and 21 to 9% ($P < 0.001$), respectively, between 1998 and 2000 and 2001 and 2003.[5]

Surveys differed in the indicators used to measure faithfulness—either in the definition of non-regular or casual partner or in the length of period over which the indicator was measured. The indicator used most frequently was one or more non-regular partners (defined as being a non-marital, non-cohabiting partner) in the past 12 months, which could be compared for 15–29-year-olds for both sexes in two ZDHS surveys (1999 and 2005) and five PSI surveys (2001, 2003, 2005, 2006 and 2007) (Figure 5b). The ZDHS data indicate reductions in reports of non-regular partners from 57% (95% CI 53.5–60%) and 15.5% (14–17%) in 1999 to 47% (44–50%) and 14% (13–16%) in 2005, for men and women, respectively. In addition, the percent of sexually-experienced men (aged 15–49 years) that reported having paid for sex in the past year fell from 7.2% (95% CI 5.6–8.9%) in 1999 to 3.6% (3.0–4.2%) in 2005. For men, the PSI estimates are consistently lower than the corresponding ZDHS estimates, possibly due to differences in the survey methods (e.g. in the wordings of the questions). However, these data also show a substantial reduction in non-regular partners between 2001 (32%, 95% CI 29–35%) and 2003 (21%, 19–23.5%), after which the percentages remained close to the 2003 level through

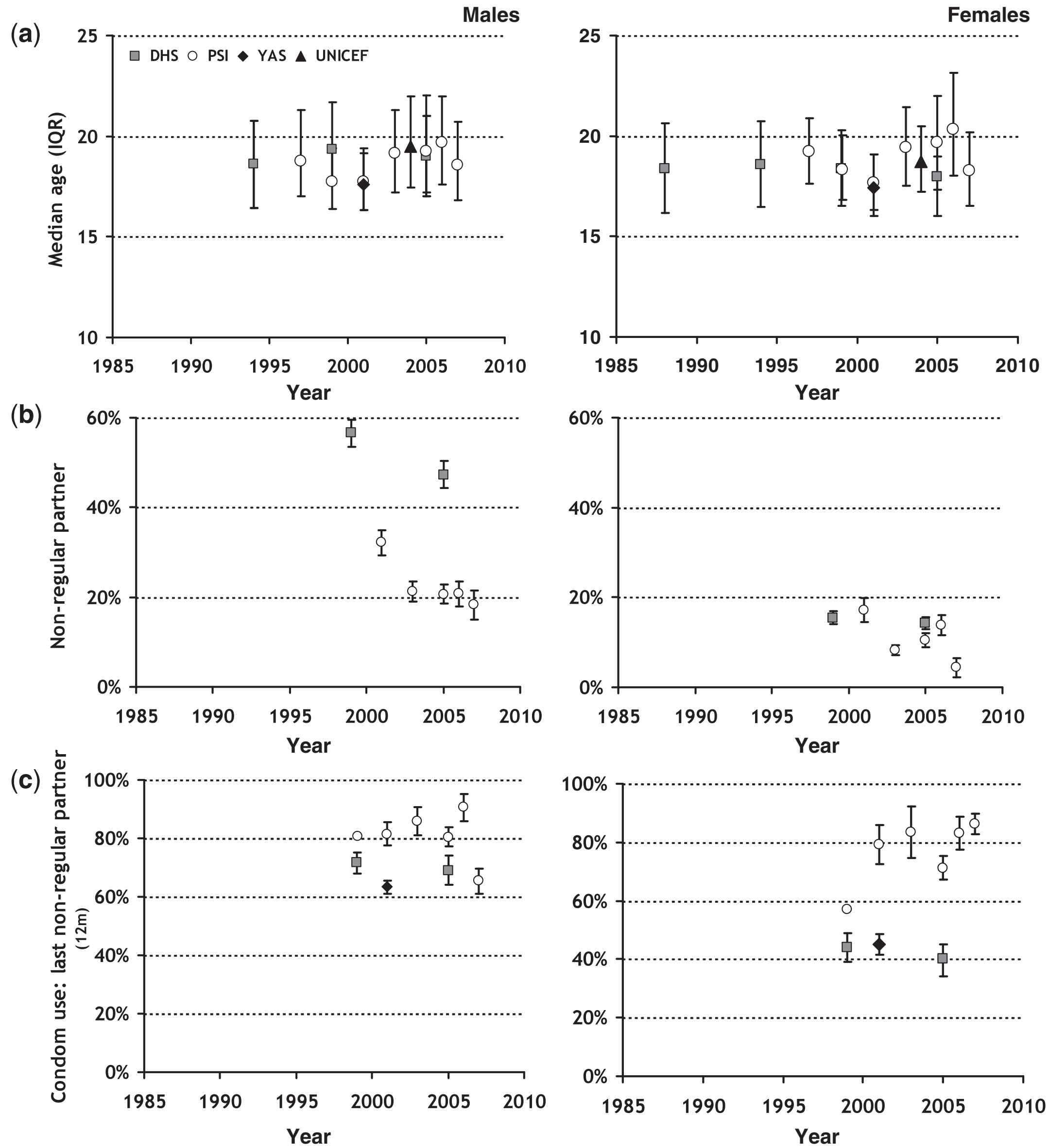

Figure 5 Trends in sexual behaviour. Estimates from national surveys: (**a**) median age at first sex for respondents aged 15–24 years at date of survey by sex calculated using survival analysis; (**b**) proportions of respondents aged 15–29 years at interview reporting a non-regular sexual partner in past 12 months; (**c**) proportions of respondents aged 15–29 years at interview with a non-regular sexual partner in the past 12 months who reported using a condom during last sex with such a partner. Estimates shown in graph (a) with IQR and graphs (b) and (c) with 95% CI. *Sources:* Zimbabwe Demographic and Health Surveys,[16,27–29] Population Services International,[30] Zimbabwe Ministry of Health and Child Welfare[32] and UNICEF[33]

to 2007. For women, the estimates are unstable but, again, suggest a reduction between 2001 (17%, 14.5–20%) and 2003 (8%, 7–9%). In the Manicaland study, the proportion of men (aged 17–54 years) reporting a recent casual partner fell by 49% over the period 1998 to 2003, from 25.9% (95% CI, 24.1–27.9%) to 13.2% (11.5–15.0%). A smaller decline was observed for women (aged 15–44 years)—from 7.5% (6.5–8.6%) to 5.9% (4.9–7.0%).[5]

Data on condom use at last sex with a non-regular sexual partner in the past 12 months were available for 15–29-year-olds from nine surveys spanning the period 1999–2006 (Figure 5c). Condom use with non-regular partners was already high by the late 1990s; thereafter, the ZDHS (and Young Adult Survey 2002) estimates are generally lower than those from the PSI surveys but neither shows a clear trend. In Manicaland, consistent condom use with recent casual partners remained at quite a high level in men (aged 17–54 years)—41.6% (95% CI 33.7–49.4%) in 1998–2000 vs 42.2% (37.1–47.3%) in 2001–03—and increased in women (aged 15–44 years) from 26.2% (18.9–33.6%) to 36.5% (26.0–46.9%).[5]

Discussion

We assembled, analysed and assessed, for the first time, all previously published and unpublished data available on trends in HIV prevalence in Zimbabwe from the onset of the epidemic in the 1980s. These data provide a consistent picture of a decline in HIV prevalence starting in the late 1990s and continuing up to 2006. We also presented the first comparisons of data on HIV incidence measured in cohort studies of comparable populations at different time points and new analyses of data from multiple sources on trends in mortality since the onset of the HIV epidemic. These data show that the decline in HIV prevalence was driven by a combination of falling HIV incidence and high mortality.

HIV incidence fell after 1990, reflecting the saturation of infection within high-risk groups that occurs as epidemics mature in heterogeneous populations, and led to prevalence stabilizing by 1997–2002.[6] However, mathematical model simulations of the HIV epidemic in Zimbabwe carried out in the review (details published elsewhere)[34,43] indicated that the pace of the decline in HIV prevalence could not have occurred without changes in behaviour or other risk factors, probably between 1999 and 2004. By conducting secondary analyses and triangulating all data available on sexual behaviour, we found evidence for substantial reductions in the proportion of individuals (particularly men) reporting non-regular partners, occurring precisely during this period. Although condom use within non-regular partnerships did not increase after 1999, the pre-existing high level of use (which the Manicaland data suggest was often ‘consistent’ by this time) contributed to the subsequent low proportion of men having sex without condoms with non-regular partners. Furthermore, earlier increases in condom use contributed to the fall in HIV incidence by reducing the reproductive rate of transmission closer to the tipping point (i.e. the point at which the net reproductive number $R_t < 1$) at which further reductions in risk behaviour can have a substantial impact on the epidemic.[44] The data sources provide inconsistent information on trends in age at first sex but even the largest delays found in the Manicaland data are too small to have contributed to the overall decline in HIV prevalence.[45]

The extent of recent international migration from Zimbabwe is substantial albeit difficult to quantify. However, the limited data did not provide evidence for selective migration of HIV-infected individuals and model simulations of alternative scenarios for the extent and selectivity of migration showed it was unlikely to have contributed greatly to the decline in HIV prevalence.

The high level of internal consistency in the wide range of data and indicators examined in the review indicate that the main findings are robust. However, the detailed results should be treated with some caution since estimates for trends in the different indicators can be subject to temporal changes in bias. The national sentinel surveillance HIV prevalence trends may reflect improvements in diagnostic testing and logistical procedures,[4] whereas the trends in HIV incidence and sexual behaviour could be distorted by differences in survey procedures and, in the latter case, by changes in social desirability bias.[46] The estimates of trends in mortality are adjusted for temporal variations in the coverage of census, survey and vital registration systems but some residual inaccuracy may remain and estimates more distant from the survey date may be distorted by recall bias.[23]

Zimbabwe is the first country in southern Africa to record a convincing decline in HIV prevalence. Prevalence declines in urban and rural areas of Ethiopia and Rwanda, and parts of Malawi and Niger have also been associated with changes in sexual behaviour (most notably reductions in partner numbers), whereas epidemic stabilization in other countries (including Cote d’Ivoire and Burundi) could feasibly only reflect the natural evolution of the epidemic.[1] The controversy that has surrounded the earlier decline in Uganda[47–49] demonstrated the need for comprehensive collation and careful review of epidemiological and behavioural data to establish a sound basis for consensus on the contributions of reductions in HIV incidence and sexual risk behaviour to declines in HIV prevalence. The current study shows that these contributions probably have been substantial in Zimbabwe and therefore are very encouraging. Further analysis and triangulation, including qualitative investigations, will be necessary to elucidate the reasons why behaviour changed. The decline in HIV prevalence also reflects a continuing period of sustained crisis-level mortality and, in 2008, it is still the case that one in every seven adults in Zimbabwe is infected with a life-threatening virus. There is much, therefore, that remains to be done.

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KEY MESSAGES

- HIV prevalence fell substantially in Zimbabwe between the late 1990s and 2006.
- Reductions in the proportions of men (particularly) and women with non-regular sexual partners and sustained high levels of condom use were recorded during this period and contributed to the decline in HIV prevalence.
- Selective migration of infected individuals was not a major factor contributing to the HIV decline in Zimbabwe.
- AIDS mortality contributed to the stabilization and decline in HIV prevalence in Zimbabwe and remained at crisis levels in the mid-2000s.

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