Sex Differences in HIV Prevalence Persist over Time: Evidence from 18 Countries in Sub-Saharan Africa

Hanne K. Hegdahl*, Knut M. Fylkesnes, Ingvild F. Sandøy

Centre for International Health, University of Bergen, Bergen, Norway

* hannekeyserhegdahl@gmail.com

Abstract

Objective

The aim of this study was to examine changes over time in the female: male HIV prevalence ratio in 18 countries in Sub-Saharan Africa, overall and when stratified by area of residence, educational attainment and marital status.

Methodology

We used data from the Demographic and Health Surveys, which are nationally representative household surveys. By using data from 18 countries with at least two survey rounds with HIV testing, and dividing the countries into three regions (Western/Central, Eastern and Southern) we were able to examine cross-country and regional changes in the female: male HIV prevalence ratio over time. Logistic regression was used to estimate female: male HIV prevalence ratios in urban versus rural areas and for different categories of education and marital status. To assess changes over time, we compared the confidence intervals of the prevalence ratios.

Results

The female: male HIV prevalence ratio was above one in all countries in at least one survey round for both ages 15–24 years and 25–49 years. In 13 out of 18 countries the prevalence ratio was higher for the younger age group compared to the age group 25–49 years (3 significant) and this difference in prevalence ratios between the age groups did not change over time. Overall, there was a higher frequency of increasing than decreasing prevalence ratios. The gender disparity was greater among those who were married/living together than among the never-married, and over time, the ratio was more stable among the married/living together. The study found no clear differential changes by education.

Conclusion

Women continue to carry the greater burden of HIV in Sub-Saharan Africa and there is no clear pattern of change in the gap between men and women as the direction and magnitude of change in the prevalence ratios varied greatly.

Introduction

More than 30 years since it was first recognised, HIV continues to be a worldwide problem, with sub-Saharan Africa (SSA) being the region most severely affected by the epidemic. At the end of 2013, 35 million people were living with HIV globally, 24.7 million of which live in SSA [1]. Despite recent encouraging trends with declining HIV incidence in most SSA countries, gaps between different groups still remain, especially between men and women. In other regions of the world, more men than women are infected with HIV because epidemics are concentrated among men who have sex with men, injecting drug users, and sex workers and their male clients [1, 2]. In SSA however, heterosexual transmission has been the primary route, and the epidemics have spread to the general population. It is estimated that women account for 58% of the people living with HIV (PLWH) in the region, a skewed distribution that has been existing for years, and women on average acquire HIV as much as 5–7 years earlier than their male peers [1].

There are several explanations for why women in SSA are more vulnerable to contracting HIV than men. Importantly, women have higher biological susceptibility to HIV and STIs than men because of a larger surface area of mucous membrane being exposed during sexual intercourse and because of hormonal suppression of the immune system in the female genital tract during the secretory stage of the menstrual cycle [3, 4]. In addition to the higher biological susceptibility of women to HIV, sociodemographic factors such as gender-based violence, age discrepancy in relationships and limited access to education are key elements placing women in SSA at increased risk of HIV [5, 6].

However, the gender gap is not the only example of differences in HIV prevalence between subgroups. Urban populations have for many years exhibited higher HIV prevalence than rural populations in most SSA countries [7–10], and high educated groups have higher HIV prevalence than less educated groups [9, 11]. Studies related to marital status and HIV prevalence have differing findings, but most studies find that the divorced or widowed have higher HIV prevalence than the married and never-married [12–15]. When looking at gender disparity in relation to marital status, a study using data from 20 countries in SSA collected in the period 2003–2008 found that the gender disparity in HIV prevalence was greater among those who were unmarried (never-married/divorced/widowed) compared to the married [16].

Several studies have found declining trends in HIV prevalence among young people in different subgroups in SSA in recent years [9, 12, 13, 17–20]. However, when declines in HIV prevalence occur, they do not necessarily take place at the same speed in all subgroups. Recent declines in HIV prevalence have been shown to be steeper for urban than rural areas [9, 17]. The HIV epidemic in the region has also gradually shifted from being more severe among the higher educated than among less educated groups [21, 22] to many countries experiencing declining prevalence among the higher educated and stable or increasing prevalence among less educated young people [9, 17, 18, 23, 24].

HIV prevalence does not only depend on incidence of HIV but also on mortality of HIV. As increasing numbers of PLWH are receiving antiretroviral therapy (ART) and can live substantially longer lives, the epidemic is likely to change. For many years, more women than men have been receiving ART and women adhere better to treatment than men [25, 26]. This may affect the gender disparity in HIV prevalence because of increased mortality due to HIV and AIDS among men compared to women [26, 27]. Similarly to what has been observed in educational subgroups, it is possible that the relative burden of HIV on men and women may shift over time, and declining incidence is a clear sign that the HIV transmission patterns are changing. Therefore, the aim of this descriptive study was to assess whether there have been changes over time in the female: male HIV prevalence ratio in 18 countries in SSA, overall and when stratified by area of residence, educational attainment and marital status. Knowledge on

changes in gender disparities is important for policy makers to establish whether there is a need for more targeted preventive interventions.

Material and Methods

Survey data sources

The analyses were based on data from the Demographic and Health Surveys (DHS) and the AIDS Indicator Surveys (AIS) conducted in the period 2001 to 2014 in 18 countries in SSA (see Table 1 for a list of the countries included). We included countries with data from at least two survey rounds (three in the cases of Mali, Tanzania and Zambia) in order to assess changes over time. These surveys are nationally representative population-based surveys conducted on average every five years in several low and middle income countries. The data can be accessed free of charge from www.measuredhs.com.

The surveys were based on two-stage stratified cluster sampling. In the first stage, clusters from all regions of the countries were selected with probability proportional to size, then a pre-set number of households were randomly selected from the clusters. All women of reproductive age (15–49 years) were asked for an interview, and the same were men (aged 15–49, 15–54 or 15–59 years) in either all, every second or every third household (Table 1). It was possible to link HIV test results to the individual interviews and thus study sociodemographic factors associated with HIV.

Men and women in the households selected for interviews of men were asked to consent to blood specimens being drawn for HIV testing. All the specimens were tested with an ELISA test. With the exception of the last survey round in Zambia, where consenting individuals were offered an additional rapid HIV test in the household, HIV testing was anonymous and hence, the participants could not be provided with the test results. Instead they were given educational materials and referred to free voluntary counselling and testing (VCT). In places where distance to the VCT clinics was more than 15 kilometres, mobile VCT teams followed the interviewers.

Statistical analyses

The analyses were conducted using Stata 13. They were adjusted for the survey design using the clustered robust option in Stata and sampling weights were applied to obtain nationally representative estimates. Indeterminate HIV test results were not taken into account and we did not distinguish between HIV-1 and HIV-2 positive status. Individuals with a valid HIV test result and information on age, sex and place of residence (urban/rural) were included in the analysis. All analyses were stratified by sex and place of residence, and conducted for two age categories (15–24 years and 25–49 years). A separate age category for young people was chosen because HIV prevalence in this age group can be used as a proxy for incidence. Men above 49 years of age were excluded in order to match the age distribution of the female participants. We adjusted for age as a continuous variable in the analyses of young people aged 15–24 years and as a categorical variable for the age group 25–49 years.

Crude and age-adjusted log-binomial regression was used to estimate HIV prevalence ratios between men and women in urban versus rural areas, at two educational levels (low versus high) and for two different categories of marital status (never married versus married/living together). To assess if there had been any changes in the prevalence ratio between the two (three) rounds of surveys, we added an interaction term between sex and time to the regression analyses. For Mali and Zambia it was not possible to link the first survey round to the latter rounds because the first rounds did not include clusters, thus we used comparison of confidence intervals to assess changes over time for these two countries. In the text we focus on the adjusted results unless there were any substantial differences between the crude and the adjusted analysis.

Table 1. Countries included and details of survey, by region.

Region	Country	Year of survey	Sample size (HH)	Response rate (%)		HIV testing rate (%)		Frequency of male questionnaires (HH)
				Men	Women	Men	Women	
Western/Central Africa	**Burkina Faso**	2003	9 097	90.5	96.3	85.8	92.3	1/3
		2010	14 424	97.3	98.4	94.4	96.7	1/2
	Cameroon	2004	10 462	93.0	94.3	89.9	92.1	1/2
		2011	14 214	95.6	97.3	93.0	94.7	1/2
	DR Congo	2007	8 886	95.4	96.7	87.0	91.0	1/2
		2013–14	18 171	97.4	98.6	94.0	96.0	1/2
	Côte d'Ivoire	2005	4 368	87.5	89.8	76.3	79.1	all
		2011–12	9 686	90.5	92.7	78.4	85.3	1/2
	Guinea	2005	6 282	94.5	97.2	88.2	92.5	1/2
		2012	7 109	96.7	98.0	94.4	96.6	1/2
	Liberia	2007	6 824	92.8	95.2	80.9	87.7	all
		2013	9 333	95.4	97.6	88.5	92.2	1/2
	Mali	2001	12 331	83.8	94.9	75.6	85.2	1/3
		2006	12 998	90.6	96.6	85.0	93.2	1/3
		2012–13	10 105	93.2	95.9	80.4	91.7	1/2
	Niger	2006	7 660	92.4	95.6	85.2	92.0	1/2
		2012	10 750	88.4	95.4	80.2	90.5	1/2
	Senegal	2005	7 412	86.0	93.7	75.5	84.5	1/3
		2010–11	7 902	87.0	92.7	78.5	86.0	1/3
	Sierra Leone	2008	7 284	92.6	94.0	86.7	89.5	1/2
		2013	12 629	96.4	97.2	90.2	98.9	1/2
Eastern Africa	**Kenya**	2003	8 561	85.5	94.0	70.3	76.3	1/2
		2008–09	9 057	88.6	96.3	79.4	86.4	1/2
	Ethiopia	2005	13 721	89.0	95.6	75.6	83.4	1/2
		2011	16 702	88.7	95.0	81.9	89.4	all
	Rwanda	2005	10 272	97.2	98.1	95.6	97.3	1/2
		2010	12 540	98.7	99.1	98.2	99.0	1/2
	Tanzania	2003–04	6 499	91.3	95.9	77.0	83.5	all
		2007–08	8 497	87.9	96.0	79.8	89.5	all
		2011–12	10 040	89.0	96.0	79.3	90.2	all
Southern Africa	**Zambia**	2001–02	7 126	88.7	96.4	80.1	81.1	1/3
		2007	7 164	91.0	96.5	72.2	77.1	all
		2013–14	15 920	91.1	96.2	83.7	90.4	all
	Zimbabwe	2005–06	9 285	81.9	90.2	63.4	75.9	all
		2010–11	9 756	85.8	93.3	69.9	80.6	all
	Lesotho	2004	8 592	84.6	94.3	68.0	80.7	1/2
		2009	9 391	95.0	97.9	88.1	93.8	1/2
	Malawi	2004	13 664	85.9	95.7	63.3	70.4	1/3
		2010	24 825	92.2	96.9	84.1	90.9	1/3

HH: households

The analyses including education and marital status were only conducted for the age group 15–24 years to capture differential changes in recent infections. In order to increase the power to detect changes over time, the latter analyses were done on data pooled for three regions (Western/Central, Eastern and Southern Africa). The first wave of surveys for Mali (2001) and Zambia (2001–02) were not included in the regional analyses since the HIV datasets from these surveys could not be linked to information such as education and marital status in the female and male questionnaires, instead we used data from the second and third wave of surveys for these countries. The DHS sampling weights are normalised by dividing each weight by the average of the initial weights so that the sum of normalised weights equal the sum of cases over the entire sample. These weights are country specific, therefore the country sampling weights were denormalised according to the following formula for the regional analysis:

$$\begin{aligned}
\text{Denormalised weight} \\
= \text{weight} \times (\text{total number of women and men aged } 15 \\
- 49/54/59 \text{ years in the country at the time of survey})/ \\
(\text{number of women and men aged } 15 - 49/54/59 \text{ interviewed in the survey})
\end{aligned}$$

In countries or regions where the statistical software was unable to provide a female: male HIV prevalence ratio due to prevalence of 0% in either of the groups (male or female), we judged the relative difference of the prevalence ratios based on the estimates of the HIV prevalence.

Ethical considerations

The DHS methodology has been approved by the ICF International Institutional Review Board (IRB) in the US. In addition, the DHS protocols have been approved by IRBs or ethical committees in the host countries (27–65). Before each interview and HIV test was conducted, an informed consent statement was read to the respondent. This statement emphasised that the respondents could refuse to answer questions, to decline testing for HIV and that they could terminate participation at any time. For minors, parental or guardian consent was obtained in addition to the respondents' assent. Verbal informed consent was sought by the interviewer reading a prescribed statement to the respondent and recording in the questionnaire whether or not the respondent consented (or provided assent on behalf of minors). Then the interviewer signed his or her name attesting to the fact that he/she read the consent statement to the respondent. Interviews and biomarker testing were conducted as privately as possible, and by assigning each respondent's data files with identifier numbers that were destroyed after data processing, the respondents' identities and results from interviews and HIV testing were kept strictly confidential and anonymous.

Results

Characteristics of study participants and response rates

The response rate varied from 81.9 to 98.7% among men and from 89.8 to 99.1% among women, and of those eligible for HIV testing, the testing rate was > 70% except in Malawi, Zimbabwe and Lesotho (Table 1). The total sample sizes varied from 4368 to 24825 households. More detailed descriptions can be found elsewhere [28–66].

Changes over time in HIV prevalence ratio by urban/rural residence

Each country separately, 25–49 years. Table 2 shows that the female: male HIV prevalence ratio was above 1 in both survey rounds and in both urban and rural areas in 11 countries. Overall, nine of 18 countries had higher female: male ratios in urban than rural sites in

Table 2. Age-adjusted female: male HIV prevalence ratio (25–49 years) by country and urban/rural residence.

	Urban					Rural				
Country	**Female**		**Male**		**PR (95% CI)**	**Female**		**Male**		**PR (95% CI)**
	HIV+ (%)	**n**	**HIV+ (%)**	**n**		**HIV+ (%)**	**n**	**HIV+ (%)**	**n**	
Burkina Faso										
2003	5.82	466	5.08	370	1.18 (0.57–2.44)	1.38	2 019	2.11	1 230	0.65 (0.38–1.11)
2010	4.17	1 413	1.77	1 282	2.39 (1.32–4.34)	1.01	3 718	0.72	2 544	1.44 (0.87–2.40)
Cameroon										
2004	10.76	1 277	8.09	1 184	1.33 (1.05–1.68)	5.77	1 530	4.18	1 343	1.38 (1.04–1.84)
2011	9.50	1 917	5.18	1 659	1.83 (1.38–2.44)	5.98	2 197	4.27	1 860	1.40 (1.11–1.77)
DR Congo										
2007	3.68	1 223	1.56	983	2.42 (1.36–4.31)	1.41	1 458	0.37	1 331	3.76 (1.37–10.4)
2013–14	3.47	1 831	0.98	1 422	3.63 (1.93–6.82)	1.27	3 718	0.58	3 035	2.28 (1.22–4.29)
Côte d´Ivoire										
2005	11.54	1 027	5.45	805	2.13 (1.35–3.34)	8.52	1 504	4.17	1 458	2.05 (1.29–3.26)
2011–12	8.25	1 084	5.26	911	1.61 (1.15–2.23)	4.68	1 678	3.24	1 449	1.46 (1.01–2.12)
Liberia										
2007	3.11	1 628	3.08	1 195	1.03 (0.65–1.62)	1.37	2 374	0.76	2 098	1.77 (0.96–3.25)
2013	4.34	942	3.91	804	1.11 (0.64–1.93)	1.50	1 774	0.84	1 620	1.78 (0.80–3.97)
Guinea										
2005	5.81	607	1.46	401	4.10 (1.72–9.80)	1.02	1 882	1.08	1 034	0.93 (0.44–1.95)
2012	5.47	934	2.24	737	2.44 (1.33–4.48)	1.39	1 856	1.54	1 165	0.92 (0.55–1.52)
Mali										
2001	4.10	522	3.11	401	1.32 (0.85–2.07)	2.00	1 817	1.51	1 203	1.28 (0.95–1.73)
2006	2.93	891	1.88	697	1.58 (0.86–2.90)	1.54	1 924	0.88	1 339	1.68 (0.74–3.82)
2012–13	2.68	871	2.71	538	1.03 (0.53–1.99)	1.12	2 402	0.67	1 643	1.70 (0.76–3.80)
Niger										
2006	2.48	845	2.46	612	1.00 (0.47–2.14)	0.46	1 912	0.71	1 118	0.66 (0.22–2.03)
2012	1.56	873	0.92	596	1.72 (0.72–4.13)	0.28	2 465	0.46	1 444	0.68 (0.28–1.62)
Senegal										
2005	1.32	1 021	0.79	665	1.68 (0.77–3.67)	1.13	1 454	0.81	801	1.46 (0.58–3.65)
2010–11	1.50	1 169	0.65	804	2.26 (0.67–7.68)	0.91	1 989	1.02	1 152	0.95 (0.52–1.71)
Sierra Leone										
2008	3.10	852	3.09	660	0.98 (0.56–1.71)	1.31	1 478	0.80	1 188	1.63 (0.67–3.98)
2013	2.88	1 705	3.01	1 382	0.95 (0.47–1.94)	1.34	3 066	0.87	2 366	1.55 (0.92–2.61)
Ethiopia										
2005	12.32	812	4.82	557	2.57 (1.63–4.05)	0.72	2 642	1.05	2 104	0.68 (0.34–1.35)
2011	9.35	2 524	5.03	2 009	1.89 (1.39–2.56)	1.10	6 543	0.70	5 083	1.58 (0.94–2.67)
Rwanda										
2005	12.45	691	9.44	548	1.34 (1.00–1.81)	3.84	2 514	2.71	1 783	1.43 (1.03–1.99)
2010	12.70	654	8.14	627	1.44 (1.08–1.92)	4.04	3 355	2.86	2 456	1.39 (1.08–1.80)
Kenya										
2003	16.10	547	11.15	463	1.43 (1.03–2.00)	9.15	1 310	6.01	1 026	1.54 (1.17–2.02)
2008–09	13.94	637	5.08	597	2.72 (1.58–4.66)	9.17	1 565	7.56	1 062	1.22 (0.93–1.59)
Tanzania										
2003–04	17.55	836	12.75	613	1.34 (1.02–1.77)	7.48	2 691	6.91	2 185	1.08 (0.86–1.36)
2007–08	14.46	1 106	10.19	686	1.43 (1.07–1.91)	6.72	4 020	6.27	2 836	1.07 (0.86–1.34)
2011–12	12.14	1 408	7.35	916	1.69 (1.18–2.43)	7.07	4 737	5.29	3 293	1.35 (1.12–1.63)

(Continued)

Table 2. (*Continued*)

Urban						Rural					
Country	Female		Male		PR (95% CI)		Female		Male		PR (95% CI)
	HIV+ (%)	n	HIV+ (%)	n			HIV+ (%)	n	HIV+ (%)	n	
Lesotho											
2004	39.79	439	31.93	226	1.23 (0.92–1.64)		33.16	1 210	32.89	741	1.03 (0.90–1.18)
2009	39.44	563	33.72	319	1.18 (1.01–1.38)		35.92	1 569	30.47	1 074	1.17 (1.03–1.33)
Malawi											
2004	22.69	176	26.84	205	0.88 (0.60–1.28)		15.57	1 452	12.37	1 187	1.26 (1.03–1.54)
2010	31.26	570	20.47	453	1.52 (1.17–1.97)		15.23	3 768	11.26	3 015	1.37 (1.19–1.57)
Zambia											
2001–02	36.85	357	29.91	308	1.24 (1.02–1.51)		15.53	819	12.71	702	1.23 (0.98–1.53)
2007	32.72	1 358	24.71	1 099	1.35 (1.16–1.57)		13.83	1 987	13.26	1 719	1.04 (0.89–1.22)
2013–14	28.98	4 100	21.05	3 146	1.40 (1.26–1.56)		13.12	4 958	11.21	4 058	1.19 (1.07–1.31)
Zimbabwe											
2005–06	31.57	1 243	26.49	791	1.18 (1.02–1.36)		28.71	2 839	23.84	1 798	1.22 (1.10–1.34)
2010–11	27.92	1 508	19.35	950	1.41 (1.21–1.63)		23.76	3 095	19.21	2 176	1.23 (1.12–1.36)

PR: Prevalence ratio

both survey rounds, and among the rest, seven had a ratio that was higher in urban sites in one of the survey rounds. However, most of these differences were insignificant.

Assessment of changes over time shows that in urban areas, the female: male prevalence ratio increased from the first to the last survey round in 12 countries and decreased in four countries (Figs 1c, 2c and 3c). However, the change was only significant in Malawi, where there was an increase from 0.88 to 1.52 (Fig 3c). In rural areas seven countries had increasing and nine had decreasing prevalence ratios but none of the changes were significant (Figs 1d, 2d and 3d). The remaining ratios were stable.

Zambia, Tanzania and Mali were the only countries with data from three points in time, making it possible to assess trends in the HIV prevalence ratios. Table 2 shows that in Mali, there was an overall decrease in the ratio in urban areas and an increase in rural areas. In Zambia, the ratio increased from 1.24 to 1.40 in urban areas, whereas in rural areas it decreased from the first to the second survey round, only to increase again in the third round (from 1.23 to 1.04 to 1.19). In Tanzania, the ratio increased in both urban and rural areas (from 1.34 to 1.69 and from 1.08 to 1.35, respectively, Fig 2c and 2d). None of the changes in either of the countries were significant.

Each country separately, 15–24 years. As with the older age group, the results for the age group 15–24 years (S1 Table) show that all countries had female: male HIV prevalence ratios above 1 in both urban and rural areas in at least one of the survey rounds. There were no significant differences in the prevalence ratios between urban and rural areas. In 13 out of 18 countries, the prevalence ratio was higher in this age group compared to the age group 25–49 years (3 of these differences were significant). The differences in prevalence ratio between the age groups did not change from the first to the last survey.

The female: male HIV prevalence ratio decreased significantly from the first to the second survey round in urban Malawi, whereas it increased significantly in rural Guinea (Figs 1b and 3a, respectively). Tanzania, Zambia and Mali showed differing trends. In Tanzania, there was an increase in the ratio from the first to the third round in both urban and rural areas (despite
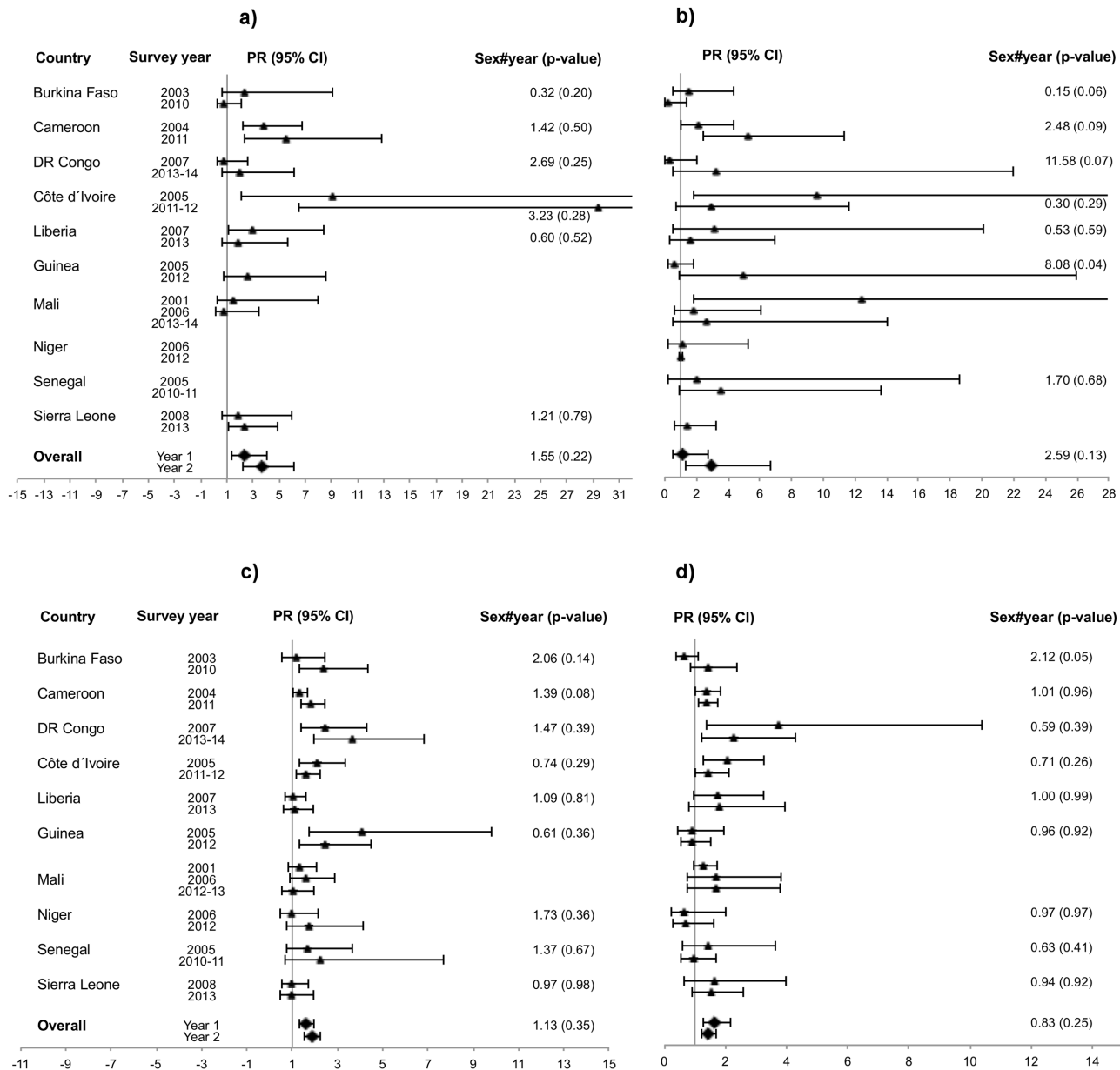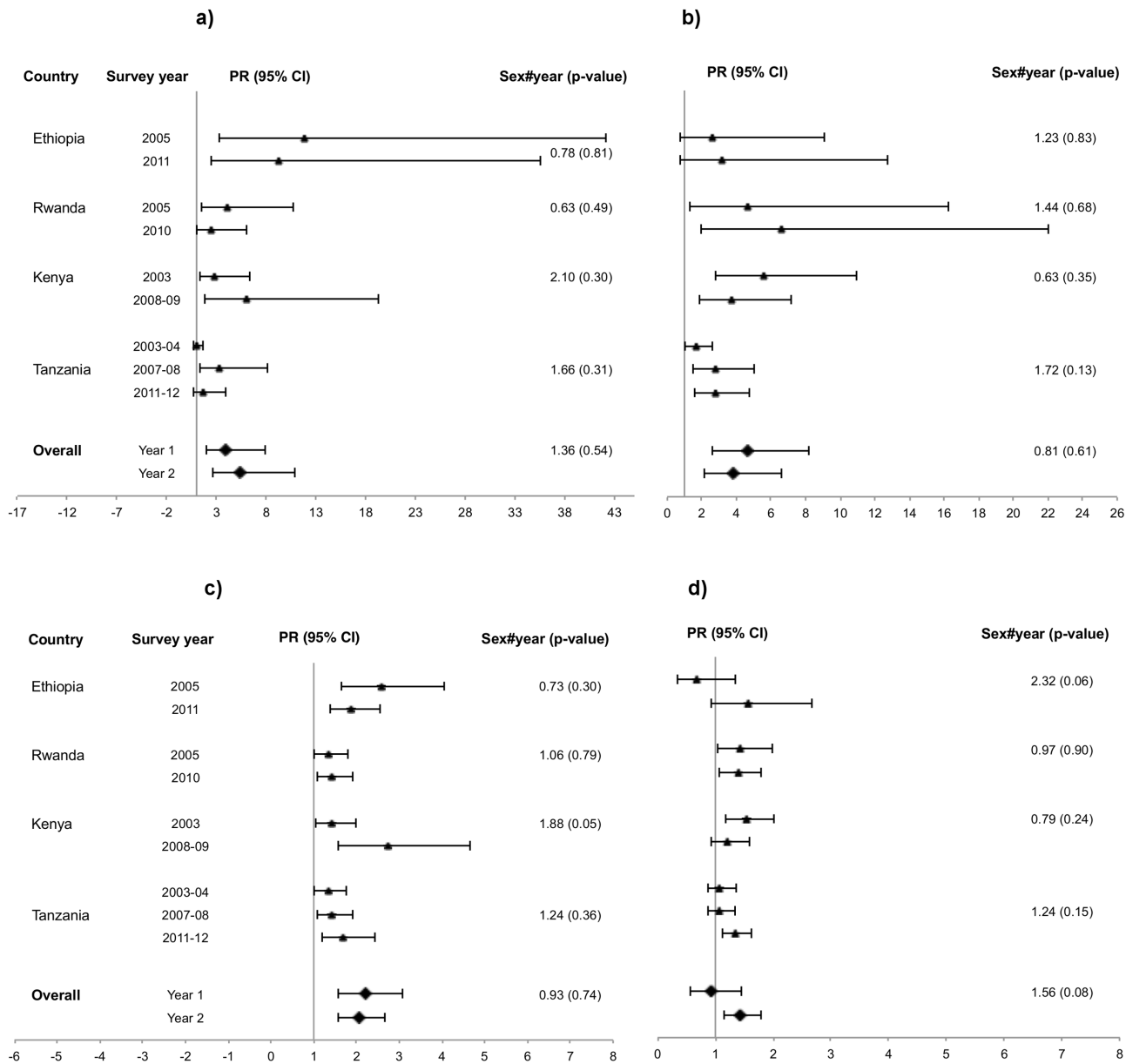
Fig 1. Western/Central Africa, age-adjusted female: male HIV prevalence ratios. (a) Urban, 15–24 years. (b) Rural, 15–24 years. (c) Urban, 25–49 years. (d) Rural, 25–49 years.

doi:10.1371/journal.pone.0148502.g001

a decrease from the second to the third round in urban areas), however not significant ([Fig 2a and 2b](#)). In Zambia, there was a steady and significant decrease, both in urban and rural areas, over the three survey rounds. The decline was particularly steep in urban areas of Zambia, where the ratio decreased from 4.30 in the first round to 1.45 in the last round due to prevalence declines in females vs. an inverse time trend in males. Mali had no clear trends ([S1 Table](#)).

Regional, 25–49 years. When data for different countries was pooled at regional level ([Table 3](#)), the analysis showed that the female: male HIV prevalence ratio was higher in urban
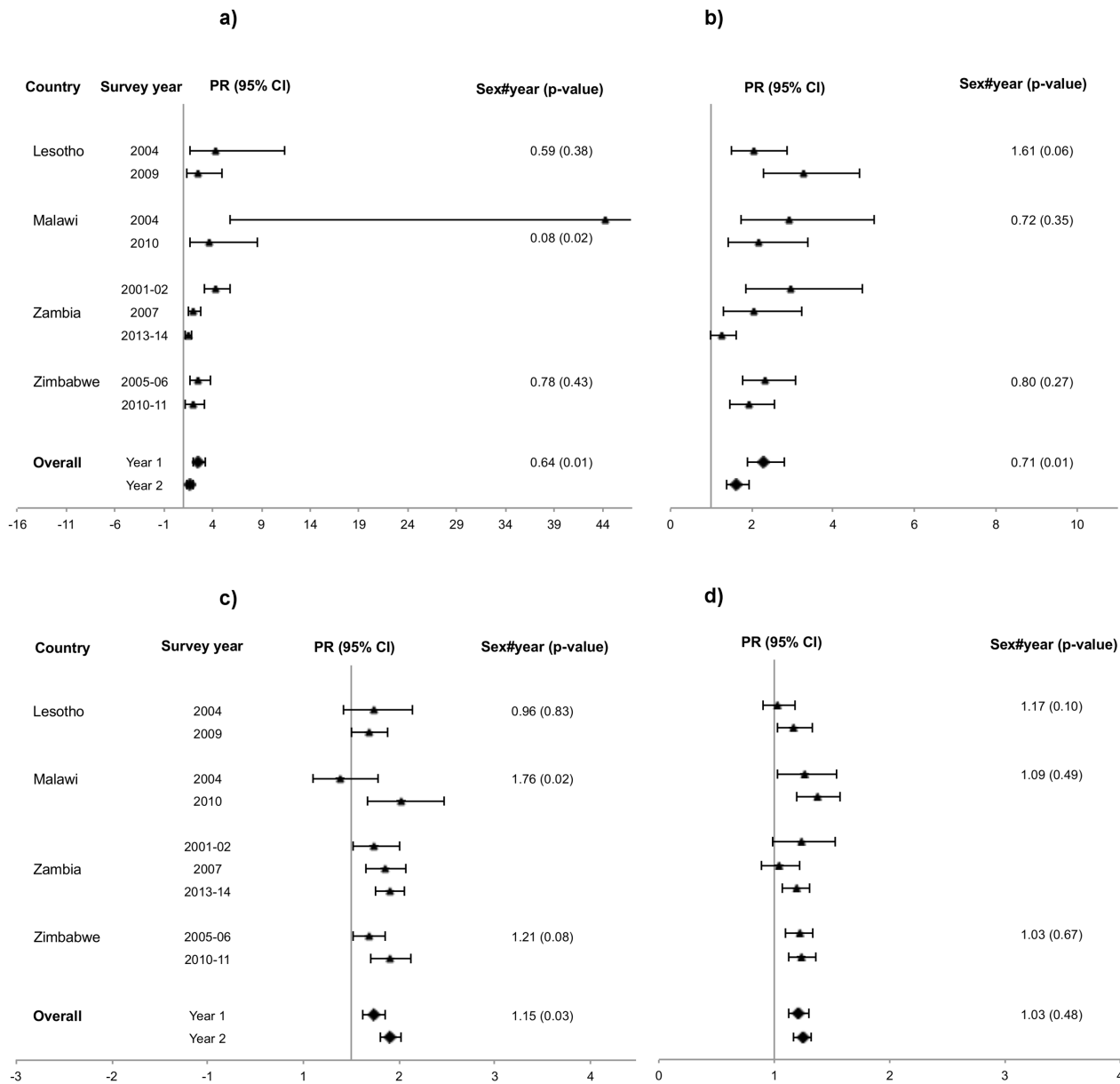
Fig 2. Eastern Africa, age-adjusted female: male HIV prevalence ratios. (a) Urban, 15–24 years. (b) Rural, 15–24 years. (c) Urban, 25–49 years (d) Rural, 25–49 years.

than in rural areas, however mostly insignificant. The only significant change over time was an increase in the ratio in urban Southern Africa (Fig 3c).

Regional, 15–24 years.   The regional results for the age group 15–24 years showed that in Southern Africa there was a significant decrease over time in the HIV prevalence ratio in both urban and rural areas (Table 3 and Fig 3a and 3b). The HIV prevalence ratio was higher in the age group 15–24 years compared to the age group 25–49 years in all three regions, significantly so in Eastern and Southern Africa. In the age group 25–49 years, the ratio ranged from 0.92 to 2.20, whereas in the younger age group it ranged from 1.16 to 5.43.

Fig 3. Southern Africa, age-adjusted female: male HIV prevalence ratios. (a) Urban, 15–24 years. (b) Rural, 15–24 years. (c) Urban, 25–49 years (d) Rural, 25–49 years.

doi:10.1371/journal.pone.0148502.g003

Changes in HIV prevalence ratio by marital status

Regional, 15–24 years. Analysis among 15–24 year olds showed that the ratio tended to be higher among those married/living together compared to the never married (S2 Table). In Southern Africa, the prevalence ratio significantly decreased among never-married from the first to the second survey round in both urban and rural areas.

Changes in HIV prevalence ratio by education

Regional, 15–24 years. Analyses by educational level indicated few clear changes. The only region with significant changes in the HIV prevalence ratios by educational level was

Table 3. Age-adjusted female: male HIV prevalence ratio by region and urban/rural residence.

Region	Urban					Rural				
	Female		Male		PR (95% CI)	Female		Male		PR (95% CI)
	HIV+ (%)	n	HIV+ (%)	n		HIV+ (%)	n	HIV+ (%)	n	
Western and Central Africa					25–49 years					
1st round	5.89	12 337	3–60	9 739	1.63 (1.34–1.99)	2.50	20 523	1.49	15 614	1.67 (1.28–2.17)
2nd round	4.96	12 739	2.67	10 135	1.87 (1.56–2.24)	1.79	24 863	1.28	18 278	1.44 (1.20–1.72)
Eastern Africa										
1st round	13.84	2 050	8.28	1 568	2.20 (1.56–3.09)	3.25	6 466	2.51	4 913	0.92 (0.58–1.45)
2nd round	10.74	3 815	5.29	3 233	2.05 (1.58–2.67)	3.12	11 463	2.18	8 601	1.43 (1.15–1.79)
Southern Africa										
1st round	31.78	3 216	25.87	2 321	1.23 (1.12–1.36)	21.08	7 488	17.45	5 445	1.21 (1.13–1.30)
2nd round	29.24	6 741	20.92	4 868	1.40 (1.30–1.52)	17.25	13 390	13.91	10 323	1.25 (1.17–1.32)
Western and Central Africa					15–24 years					
1st round	2.23	10 505	0.94	8 548	2.38 (1.39–4.07)	1.02	12 385	0.86	9 556	1.16 (0.49–2.75)
2nd round	1.48	10 606	0.39	8 376	3.67 (2.21–6.11)	1.02	14 104	0.33	10 362	2.93 (1.28–6.71)
Eastern Africa										
1st round	4.84	1 836	1.25	1 308	3.99 (2.01–7.89)	1.94	4 526	0.40	3 891	4.64 (2.62–8.20)
2nd round	1.82	3 248	0.35	2 112	5.43 (2.70–10.90)	1.32	7 754	0.34	6 496	3.78 (2.16–6.63)
Southern Africa										
1st round	11.61	2 884	4.62	2 098	2.53 (1.97–3.24)	9.17	5 519	3.62	4 477	2.31 (1.90–2.82)
2nd round	10.57	5 169	6.38	3 940	1.63 (1.33–2.01)	5.37	9 232	3.09	8 001	1.64 (1.38–1.95)

PR: Prevalence ratio

Southern Africa, where the ratios declined in the high education group in both urban and rural areas and in the low education group in urban areas (S3 Table).

Discussion

This study shows that women continue to carry the greater burden of HIV in SSA with HIV prevalence ratios consistently being above 1, and there was no clear pattern of change in the gap between men and women as the direction and magnitude of change varied greatly. Furthermore, the gender disparity tended to be larger among young people than among older adults, indicating that young women are still the most vulnerable in the SSA HIV epidemic. For the age-group 25–49 years, there was a higher frequency of increasing prevalence ratios in urban areas compared to rural areas, however, mostly non-significant. The gender disparity was greater among those who were married or living together than among the never-married. Our study showed no clear differential changes in HIV prevalence ratios by education, indicating that women are more vulnerable than men independent of educational level. Of all our findings, the clearest changes were the ones seen among the youngest in Zambia where the prevalence ratios was decreasing, and in regions where the HIV prevalence was highest, such as in Southern Africa.

Overall, the female: male HIV prevalence ratio increased more often than it decreased. The increases were primarily due to a less marked prevalence decline among women compared to men, and reflected a larger increase in prevalence among women compared to men only in 8 cases in the age-group 25–49 years and in 5 cases for the age-group 15–24 years. Differential changes in sexual behaviour in both young and older age groups may explain the increases in

prevalence ratios that we observed. Several studies from SSA investigating trends in sexual behaviour found that both women and men exhibited declining risky sexual behaviour [19, 67–69]. However, for most of the behavioural risk factors, such as sex before the age of 15 and 18 years, premarital sex and non-regular partners, the decline has been more marked among men than among women [19, 67–69]. It is thus plausible that the clearer declines in HIV prevalence among men may reflect bigger reductions in the rate of new infections among men than women. However, a study using data from three countries in SSA found that inequalities in HIV prevalence between men and women persisted even after the differential distribution of HIV risk factors and sociodemographic characteristics between men and women were controlled for [70], suggesting that biologic factors may be important in women's greater vulnerability to HIV. Another possible explanation for the increasing prevalence ratios in some countries is the recent upscaling of voluntary medical male circumcision as a prevention strategy against HIV. Male circumcision may contribute to an increase in gender inequalities in HIV as it, on a short term basis, only protects men. Incidence of HIV in women can only decrease as an indirect result of medical male circumcision when the prevalence among men has fallen, which might take a long time to occur, and it can therefore not be regarded as a prevention strategy for women. Increasing ratios could also be due to lower HIV related mortality among infected women than men. Data from several countries indicate that more women than men are tested for HIV, that women have higher CD4+ counts when initiating ART compared to men, more women than men receive ART and women tend to adhere better to treatment [25, 71, 72]. These differences are likely due to the good availability of HIV testing and treatment services in antenatal settings [25, 71, 72]. Better survival with HIV infection can lead to higher HIV prevalence among women compared to men.

Power inequality in relationships, arising from unequal access to resources, decision-making on sexual and reproductive issues traditionally being male-controlled and substantial age differences between women and their male partners, is not uncommon in SSA and places women in a socially disadvantaged position with increased risk of HIV infection [25, 73]. The greater prevalence ratio that we found among young people compared to older adults and among young married or cohabiting people compared to young people who had never been married could be explained by age-disparate relationships as young women in SSA tend to marry men that are substantially older than themselves [74]. This increases young women's risk of acquiring HIV by connecting to an older sexual network, and the largest age gaps have been found to occur in marriages and other long-term, stable relationships [74, 75].

In the analysis of change over time, we found that the prevalence ratio was more stable among the married than among the never-married. If we expect that most married couples engage in sexual intercourse on a regular basis and that never-married display greater variation in sexual activity, it is likely that the risk of acquiring HIV is more stable in married couples. It therefore seems logical to expect the ratio to change less in this group than in the never-married group. In support of our findings, a 2008 study from Rwanda and Zambia by Dunkle et al. [76] found that the risk of HIV transmission is higher within marriage or in cohabiting relationships than within non-cohabiting relationships.

We were only able to assess trends in the female: male HIV prevalence ratio in Mali, Tanzania and Zambia. Compared to the countries with data from two points in time, these three countries had clearer changes, however, we were only able to distinguish significant trends in Zambia. Among young people in Zambia there was a decrease in the prevalence ratio due to prevalence declines for women and increasing prevalence for men. In Tanzania there was a decrease in the HIV prevalence among both men and women, but due to a less marked decrease in the prevalence among women compared to men, the prevalence ratio increased in both age groups. It is difficult to find explanations for the trends in Zambia and Tanzania, and

we could not find differential changes in sexual behaviour to help explain them. In Mali there were no clear trends.

A major strength of this study was the use of large datasets that have been collected in a standardised manner which make them fairly comparable across countries and time points. To our knowledge, no previous study has examined changes in gender differences over time in so many countries in SSA, and this gave us a good opportunity to look for overall patterns at regional and sub-regional level. The response rates were high with HIV testing rates above 80% in 8 countries and above 70% in 15 countries. Non-participation and non-testing was consistently higher among men than women, and data from the reports suggest this was due to men having more frequent and longer trips away from home than women [28–66]. Those who stay away from home because they are migrant workers have in other studies from SSA been found to be at higher risk of HIV infection [77, 78]. However, of the people who did not get tested, there were more people who refused to get tested than who were absent, and we cannot exclude the possibility that the ones who refused testing had a higher risk of being infected. Thus the differential HIV testing rates may have led to an overestimation of the female: male prevalence ratios, but due to the high testing rates it is not likely that this had substantial impact on our results. Reporting bias, which can often be a concern with DHS data because the interviews are very long (particularly for women) and there are many sensitive questions, is not likely to have had an impact on the data we analysed since we only used data on age, sex, education and marital status, which usually are not regarded as sensitive information.

A limitation of the analyses was that most of the countries we included only had data on HIV prevalence from two points in time, which made it impossible to assess time trends in these countries. In addition, pooling of data from different countries masked some of the differential changes at country level within a region. It is also worth noting that the time intervals were not the same for all countries within a region. Thus changes in the prevalence ratios at regional level should be interpreted with caution. However, the advantage with pooling was that some countries had a very small proportion of HIV positive individuals in some of the subgroups, giving very wide confidence intervals for the prevalence ratios, and pooling of data gave more power to assess changes over time. Another limitation to our study was that we only had prevalence data rather than incidence data. However, prevalence changes in young people can provide indications of incidence changes, thus we focused more on the age group 15–24 in our analyses.

Conclusion

The continued vulnerability of women to HIV that we found in this study may indicate that biologic factors are important in explaining the higher HIV prevalence among women than among men and interventions need to have a stronger focus on tailored strategies for men and women. Women in SSA also face social challenges that should be reduced so that women may have the opportunity to protect themselves from HIV. Combining interventions that focus on changing the socioeconomic vulnerabilities of women with strategies increasing availability of ART and HIV testing services for men, may help eliminate the gender disparity in HIV prevalence. In conclusion it is worth pointing out the great heterogeneity of these data, which challenged the interpretation of the results. We have not, however, found any obvious or fitting explanations for this in SSA.

Supporting Information

S1 Table. Age-adjusted female: male HIV prevalence ratio (15–24 years) by country and urban/rural residence.
(XLSX)

S2 Table. Age-adjusted female: male HIV prevalence ratio by region, urban/rural residence and marital status (15–24 years).
(XLSX)

S3 Table. Age-adjusted female: male HIV prevalence ratio by region, urban/rural residence and educational level (15–24 years).
(XLSX)

S4 Table. Educational categories.
(XLSX)

Acknowledgments

Author Contributions

Conceived and designed the experiments: HKH IFS. Analyzed the data: HKH. Wrote the paper: HKH IFS KMF.

References

1.   UNAIDS. Gap Report. Geneva: UNAIDS, 2013.

2.   Murray CJL, Ortblad KF, Guinovart C, Lim SS, Wolock TM, Roberts DA, et al. Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 384(9947):1005–70.

3.   Nicolosi A, Correa Leite ML, Musicco M, Arici C, Gavazzeni G, Lazzarin A. The efficiency of male-to-female and female-to-male sexual transmission of the human immunodeficiency virus: a study of 730 stable couples. Italian Study Group on HIV Heterosexual Transmission. Epidemiology (Cambridge, Mass). 1994; 5(6):570–5.

4.   Wira CR, Fahey JV. A new strategy to understand how HIV infects women: identification of a window of vulnerability during the menstrual cycle. AIDS (London, England). 2008; 22(15):1909–17.

5.   Kelly RJ, Gray RH, Sewankambo NK, Serwadda D, Wabwire-Mangen F, Lutalo T, et al. Age differences in sexual partners and risk of HIV-1 infection in rural Uganda. J Acquir Immune Defic Syndr. 2003; 32 (4):446–51. PMID: 12640205

6.   Langen TT. Gender power imbalance on women's capacity to negotiate self-protection against HIV/ AIDS in Botswana and South Africa. African Health Sciences. 2005; 5:188–97. PMID: 16245988

7.   Garcia-Calleja JM, Gouws E, Ghys PD. National population based HIV prevalence surveys in sub-Saharan Africa: results and implications for HIV and AIDS estimates. Sexually transmitted infections. 2006; 82 Suppl 3:iii64–70. PMID: 16735296

8.   Montana LS, Mishra V, Hong R. Comparison of HIV prevalence estimates from antenatal care surveillance and population-based surveys in sub-Saharan Africa. Sexually transmitted infections. 2008; 84 Suppl 1:i78–i84. doi: 10.1136/sti.2008.030106 PMID: 18647871

9.   Kayeyi N, Fylkesnes K, Michelo C, Makasa M, Sandøy I. Decline in HIV Prevalence among Young Women in Zambia: National-Level Estimates of Trends Mask Geographical and Socio-Demographic Differences. PloS one. 2012; 7(4):e33652. doi: 10.1371/journal.pone.0033652 PMID: 22496759

10. Hajizadeh M, Sia D, Heymann S, Nandi A. Socioeconomic inequalities in HIV/AIDS prevalence in sub-Saharan African countries: evidence from the Demographic Health Surveys. International Journal for Equity in Health. 2014; 13(1):18.

11. Fortson JG. The gradient in sub-Saharan Africa: Socioeconomic status and HIV/AIDS. Demography. 2008; 45(2):303–22. PMID: 18613483

12. Kuate S, Mikolajczyk RT, Forgwei GW, Tih PM, Welty TK, Kretzschmar M. Time trends and regional differences in the prevalence of HIV infection among women attending antenatal clinics in 2 provinces in Cameroon. J Acquir Immune Defic Syndr. 2009; 52(2):258–64. doi: 10.1097/QAI.0b013e3181ab6d2e PMID: 19546813

13. Kimanga DO, Ogola S, Umuro M, Ng'ang'a A, Kimondo L, Murithi P, et al. Prevalence and incidence of HIV infection, trends, and risk factors among persons aged 15–64 years in Kenya: results from a

nationally representative study. J Acquir Immune Defic Syndr. 2014; 66 Suppl 1:S13–26. doi: 10.1097/QAI.0000000000000124 PMID: 24445338

14. Nalugoda F, Guwatudde D, Bwaninka JB, Makumbi FE, Lutalo T, Kagaayi J, et al. Marriage and the risk of incident HIV infection in Rakai, Uganda. J Acquir Immune Defic Syndr. 2014; 65(1):91–8. doi: 10.1097/QAI.0b013e3182a7f08a PMID: 24419066

15. Tenkorang EY. Marriage, widowhood, divorce and HIV risks among women in sub-Saharan Africa. International health. 2014; 6(1):46–53. doi: 10.1093/inthealth/ihu003 PMID: 24480991

16. Magadi MA. Understanding the gender disparity in HIV infection across countries in sub-Saharan Africa: evidence from the Demographic and Health Surveys. Sociology of health & illness. 2011; 33 (4):522–39.

17. Michelo C, Sandoy IF, Dzekedzeke K, Siziya S, Fylkesnes K. Steep HIV prevalence declines among young people in selected Zambian communities: population-based observations (1995–2003). BMC public health. 2006; 6:279. PMID: 17096833

18. Hargreaves JR, Howe LD. Changes in HIV prevalence among differently educated groups in Tanzania between 2003 and 2007. AIDS (London, England). 2010; 24(5):755–61.

19. Kembo J. Changes in sexual behaviour and practice and HIV prevalence indicators among young people aged 15–24 years in Zambia: an in-depth analysis of the 2001–2002 and 2007 Zambia Demographic and Health Surveys. SAHARA J: journal of Social Aspects of HIV/AIDS Research Alliance / SAHARA, Human Sciences Research Council. 2013; 10(3–4):150–62.

20. Hargreaves JR, Davey C, Fearon E, Hensen B, Krishnaratne S. Trends in Socioeconomic Inequalities in HIV Prevalence among Young People in Seven Countries in Eastern and Southern Africa. PloS one. 2015; 10(3):e0121775. doi: 10.1371/journal.pone.0121775 PMID: 25793608

21. Fylkesnes K, Ndhlovu Z, Kasumba K, Mubanga Musonda R, Sichone M. Studying dynamics of the HIV epidemic: population-based data compared with sentinel surveillance in Zambia. AIDS (London, England). 1998; 12(10):1227–34.

22. Smith J, Nalagoda F, Wawer MJ, Serwadda D, Sewankambo N, Konde-Lule J, et al. Education attainment as a predictor of HIV risk in rural Uganda: results from a population-based study. International Journal of STD & AIDS. 1999.

23. de Walque D, Nakiyingi-Miiro JS, Busingye J, Whitworth JA. Changing association between schooling levels and HIV-1 infection over 11 years in a rural population cohort in south-west Uganda. Tropical medicine & international health: TM & IH. 2005; 10(10):993–1001.

24. Hargreaves JR, Bonell CP, Boler T, Boccia D, Birdthistle I, Fletcher A, et al. Systematic review exploring time trends in the association between educational attainment and risk of HIV infection in sub-Saharan Africa. AIDS (London, England). 2008; 22(3):403–14.

25. UNAIDS. Global Report 2013. Geneva: UNAIDS, 2013.

26. Mugisha V, Teasdale CA, Wang C, Lahuerta M, Nuwagaba-Biribonwoha H, Tayebwa E, et al. Determinants of mortality and loss to follow-up among adults enrolled in HIV care services in Rwanda. PloS one. 2014; 9(1):e85774. doi: 10.1371/journal.pone.0085774 PMID: 24454931

27. Cornell M, Schomaker M, Garone DB, Giddy J, Hoffmann CJ, Lessells R, et al. Gender differences in survival among adult patients starting antiretroviral therapy in South Africa: a multicentre cohort study. PLoS Med. 2012; 9(9):e1001304. PMID: 22973181

28. Agence Nationale de la Statistique et de la Démographie (ANSD) (Sénégal) eII. Enquête Démographique et de Santé à Indicateurs Multiples au Sénégal 2010–2011. 2012.

29. Cellule de Planification et de Statistique (CPS/SSDSPF) INdISIM, INFO-STAT et ICF International. Enquête Démographique et de Santé au Mali 2012–2013. 2014.

30. Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS) DNdISedIIDeOM. Enquête Démographique et de Santé au Mali 2001. 2002.

31. Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS) DNdISedIIdMrdIEc. Enquête Démographique et de Santé du Mali 2006. 2007.

32. Central Bureau of Statistics (CBS) (Kenya) MoHMK, and ORC Macro. Kenya Demographic and Health Survey 2003. 2004.

33. Central Statistical Office (CSO) (Zambia) MoHMZ, and ICF International. Zambia Demographic and Health Survey 2013–14. 2014.

34. Central Statistical Office (CSO) MoHM, Tropical Diseases Research Centre (TDRC), University of Zambia, and Macro International Inc. Zambia Demographic and Health Survey 2007. 2009.

35. Central Statistical Office (Zambia) CBoHZ, and ORC Macro. Zambia Demographic and Health Survey 2001–2002. 2003.

36. ICF INdISIe. Enquête Démographique et de Santé et à Indicateurs Multiples du Cameroun 2011. 2012.

37. Inc CSOCZaMI. Zimbabwe Demographic and Health Survey 2005–06. 2007.

38. Inc INdlSIeMI. Enquête Démographique et de Santé et à Indicateurs Multiples du Niger 2006. 2007.

39. International CSAEaI. Ethiopia Demographic and Health Survey 2011. 2012.

40. International INdlSedlDmleI. Enquête Démographique et de Santé et à Indicateurs Multiples du Burkina Faso 2010. 2012.

41. International INdlSIeI. Enquête Démographique et de Santé et à Indicateurs Multiples de Côte d'Ivoire 2011–2012. 2012.

42. International INdlSIeI. Enquête Démographique et de Santé et à Indicateurs Multiples du Niger 2012. 2013.

43. International INdlSIGeI. Enquête Démographique et de Santé et à Indicateurs Multiples, Guinée 2012. 2013.

44. International MrdPeM. Enquête Démographique et de Santé, République Démocratique du Congo 2007. 2008.

45. International SSLSaI. Sierra Leone Demographic and Health Survey 2013. 2014.

46. International ZNSAZaI. Zimbabwe Demographic and Health Survey 2010–11. 2012.

47. Liberia Institute of Statistics and Geo-Information Services (LISGIS) (Liberia) MoHaSWL, National AIDS Control Program (Liberia), and Macro International Inc. Liberia Demographic and Health Survey 2007. 2008.

48. Liberia Institute of Statistics and Geo-Information Services (LISGIS) MoHaSWL, National AIDS Control Program (Liberia), and ICF International. Liberia Demographic and Health Survey 2013. 2014.

49. Macro CSAEaO. Ethiopia Demographic and Health Survey 2005. 2006.

50. Macro DNdlSDGeeO. Enquête Démographique et de Santé, Guinée 2005. 2006.

51. Macro INdlSedlDmleO. Enquête Démographique et de Santé du Burkina Faso 2003. 2004.

52. Macro INdlSIeO. Enquête Démographique et de Santé du Cameroun 2004. 2004.

53. Macro INdlSIeMrdlLclSCtdIeO. Enquête sur les Indicateurs du Sida, Côte d'Ivoire 2005. Report. 2006.

54. Macro INdlSdRIaO. Rwanda Demographic and Health Survey 2005. 2006.

55. Macro KNBoSKaI. Kenya Demographic and Health Survey 2008–09. 2010.

56. Macro NSONaI. Malawi Demographic and Health Survey 2010. 2011.

57. Macro SSLSaI. Sierra Leone Demographic and Health Survey 2008. 2009.

58. Macro. MoHaSWMLaI. Lesotho Demographic and Health Survey 2009. 2010.

59. Ministère du Plan et Suivi de la Mise en œuvre de la Révolution de la Modernité (MPSMRM) MrdlSPMeI. Enquête Démographique et de Santé, République Démocratique du Congo 2013–2014. 2014.

60. Ministry of Health and Social Welfare (MOHSW) (Lesotho) BoSBL, and ORC Macro. Lesotho Demographic and Health Survey 2004. 2005.

61. National Institute of Statistics of Rwanda (NISR) (Rwanda) MoHMR, and ICF International. Rwanda Demographic and Health Survey 2010. 2012.

62. National Statistical Office (NSO) (Malawi) aOM. Malawi Demographic and Health Survey 2004. 2005.

63. Ndiaye S, et Mohamed Ayad. Enquête Démographique et de Santé au Sénégal 2005. 2006.

64. Tanzania Commission for AIDS (TACAIDS) NBoSN, and ORC Macro. Tanzania HIV/AIDS Indicator Survey 2003–04. 2005.

65. Tanzania Commission for AIDS (TACAIDS) ZACZ, National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS), and Macro International Inc. Tanzania HIV/AIDS and Malaria Indicator Survey 2007–08. 2008.

66. Tanzania Commission for AIDS (TACAIDS) ZACZ, National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS), and ICF International. Tanzania HIV/AIDS and Malaria Indicator Survey 2011–12. 2013.

67. Gregson S, Gonese E, Hallett TB, Taruberekera N, Hargrove JW, Lopman B, et al. HIV decline in Zimbabwe due to reductions in risky sex? Evidence from a comprehensive epidemiological review. International journal of epidemiology. 2010; 39(5):1311–23. doi: 10.1093/ije/dyq055 PMID: 20406793

68. Kayeyi N, Fylkesnes K, Wiium N, Sandoy IF. Decline in sexual risk behaviours among young people in Zambia (2000–2009): do neighbourhood contextual effects play a role? PloS one. 2013; 8(5):e64881. doi: 10.1371/journal.pone.0064881 PMID: 23717672

69. McGrath N, Eaton JW, Barnighausen TW, Tanser F, Newell ML. Sexual behaviour in a rural high HIV prevalence South African community: time trends in the antiretroviral treatment era. AIDS (London, England). 2013; 27(15):2461–70.

70. Sia D, Onadja Y, Nandi A, Foro A, Brewer T. What lies behind gender inequalities in HIV/AIDS in sub-Saharan African countries: evidence from Kenya, Lesotho and Tanzania. Health policy and planning. 2013.

71. Druyts E, Dybul M, Kanters S, Nachega J, Birungi J, Ford N, et al. Male sex and the risk of mortality among individuals enrolled in antiretroviral therapy programs in Africa: a systematic review and meta-analysis. AIDS (London, England). 2013; 27(3):417–25.

72. Mutasa-Apollo T, Shiraishi RW, Takarinda KC, Dzangare J, Mugurungi O, Murungu J, et al. Patient retention, clinical outcomes and attrition-associated factors of HIV-infected patients enrolled in Zimbabwe's National Antiretroviral Therapy Programme, 2007–2010. PloS one. 2014; 9(1):e86305. doi: 10.1371/journal.pone.0086305 PMID: 24489714

73. Shannon K, Leiter K, Phaladze N, Hlanze Z, Tsai AC, Heisler M, et al. Gender inequity norms are associated with increased male-perpetrated rape and sexual risks for HIV infection in Botswana and Swaziland. PloS one. 2012; 7(1):e28739. doi: 10.1371/journal.pone.0028739 PMID: 22247761

74. Maughan-Brown B, Kenyon C, Lurie MN. Partner age differences and concurrency in South Africa: Implications for HIV-infection risk among young women. AIDS and behavior. 2014; 18(12):2469–76. doi: 10.1007/s10461-014-0828-6 PMID: 25047687

75. Wyrod R, Fritz K, Woelk G, Jain S, Kellogg T, Chirowodza A, et al. Beyond sugar daddies: intergenerational sex and AIDS in urban Zimbabwe. AIDS and behavior. 2011; 15(6):1275–82. doi: 10.1007/s10461-010-9800-2 PMID: 20811939

76. Dunkle KL, Stephenson R, Karita E, Chomba E, Kayitenkore K, Vwalika C, et al. New heterosexually transmitted HIV infections in married or cohabiting couples in urban Zambia and Rwanda: an analysis of survey and clinical data. Lancet. 2008; 371(9631):2183–91. doi: 10.1016/S0140-6736(08)60953-8 PMID: 18586173

77. Camlin CS, Hosegood V, Newell ML, McGrath N, Barnighausen T, Snow RC. Gender, migration and HIV in rural KwaZulu-Natal, South Africa. PloS one. 2010; 5(7):e11539. doi: 10.1371/journal.pone.0011539 PMID: 20634965

78. Magadi MA. Migration as a Risk Factor for HIV Infection among Youths in Sub-Saharan Africa: Evidence from the DHS. The ANNALS of the American Academy of Political and Social Science. 2013:136–59.