National population based HIV prevalence surveys in sub-Saharan Africa: results and implications for HIV and AIDS estimates

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Background: Sentinel surveillance among pregnant women attending antenatal clinics (ANCs) has been the main source of information on HIV trends in sub-Saharan Africa. These data have also been used to generate national HIV and AIDS estimates. New technologies and resources have allowed many countries to conduct national population based surveys that include HIV prevalence measurement, as an additional source of information on the AIDS epidemic.

Methods: The authors reviewed the reports of 20 national population based surveys from 19 countries carried out in sub-Saharan Africa since 2001. They examined the sampling methodology, HIV testing and response rates, and female:male and urban:rural prevalence ratios. They also constructed adjusted prevalence scenarios assuming different relative risks for survey non-responders.

Results: The national population based surveys vary considerably in quality, as reflected in the household response rate (ranging from 75.4% to 99.7%), women's testing rate (ranging from 68.2% to 97.3%), and men's testing rate (ranging from 62.2% to 95.4%), while for some surveys detailed response information is lacking. While 95% confidence intervals around the female:male and urban:rural prevalence ratios in individual countries are large, the median female:male ratio of the combined set of surveys results is 1.5 and the median urban:rural ratio 1.7. A scenario assuming that non-responders have twice the HIV prevalence of those who fully participated in the survey suggests that individual non-response could result in an adjusted HIV prevalence 1.03 to 1.34 times higher than the observed prevalence.

Conclusions: Population based surveys can provide useful information on HIV prevalence levels and distribution. This information is being used to improve national HIV and AIDS estimates. Further refinements in data collection, analysis, and reporting, combined with high participation rates, can further improve HIV and AIDS estimates at national and regional level.

Sentinel surveillance among pregnant women attending antenatal clinics (ANCs) has been widely used to monitor trends of the HIV epidemic in the general population.[1] In the early stages of development of HIV surveillance systems, ANC sites were selected mostly in urban areas and in areas with known high HIV prevalence.[2] HIV sentinel surveillance systems have evolved over time, according to the needs, available resources, HIV testing technologies, and increased knowledge about HIV infection. ANC based HIV surveillance systems have included more than 600 sites in sub-Saharan Africa on a regular basis. The analysis of country specific information has provided insight in the heterogeneity of the AIDS epidemic in sub-Saharan Africa and to investigate regional trends and patterns. Although the quality of the surveillance systems has varied over time, general information on HIV in sub-Saharan Africa has improved in the last few years.[3 4]

Global and regional estimates of HIV have been provided by the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) since the late 1980s and country specific estimates since 1996.[5–9] For countries with generalised epidemics, these estimates have largely been based on ANC surveillance data. However, using ANC surveillance data for making national HIV estimates has limitations, as these data do not inform about non-pregnant women or men, and because coverage of rural areas by the sentinel surveillance system in most countries is incomplete, and the assumptions and validity of these estimates have been questioned by some.[10]

Since 2001, several countries in sub-Saharan Africa have conducted national population based surveys to estimate HIV prevalence. While these surveys typically have national coverage and generate data for women and men in urban and rural areas, they also have limitations. The main limitations are the potential for bias introduced by non-response and the exclusion from the sampling frame of population groups at high risk of HIV infection.[11] The aim of this paper is to review the response rates and the results of the national population based surveys with HIV prevalence measurement that have been conducted in the last five years in sub-Saharan Africa, and to explore how the information on HIV prevalence generated by these surveys can be used to improve national HIV and AIDS estimates.

METHODS

We reviewed all available reports of national population based household surveys that included HIV prevalence measurement since 2001 in sub-Saharan African countries, including preliminary reports for four countries with a Demographic and Health Survey (DHS) or AIDS Indicator Survey (AIS). We tabulated the characteristics of the surveys, including the age range, sample size, HIV testing methods, and response rates of the surveys. Where household response was given separately for women and men, the average of the two is presented here. We analysed HIV prevalence results by urban and rural areas, and by gender, by calculating 95% confidence intervals about the reported urban:rural HIV

Abbreviations: AIS, AIDS Indicator Survey; ANC, antenatal clinic; DBS, dried blood spots; DHS, Demographic and Health Survey; HSRC, Human Sciences Research Council; RHRU, Reproductive Health Research Unit; UNAIDS, Joint United Nations Programme on HIV/AIDS; WHO, World Health Organization.

Table 1 Characteristics of population based surveys

Country	Year of survey	Type of survey	Age group		Sample size*	Type of specimen	Linkage of test results to individuals' characteristics
			Females	Males			
Burkina Faso	2003	DHS	15–49	15–59	7515	DBS	Linked
Burundi	2002	Household survey	>12 years	>12 years	5569	Venous	Linked
Cameroon	2004	DHS	15–49	15–59	9900	DBS	Linked
Congo	2003	Household survey, restricted to urban areas	15–49	15–49	3453	Venous	Linked
Equatorial Guinea	2004	Household survey	15–49	15–49	1449	DBS	Linked
Ghana	2003	DHS	15–49	15–59	9144	DBS	Linked
Guinea	2005	DHS	15–49	15–59	6377	DBS	Linked
Kenya	2003	DHS	15–49	15–59	6002	DBS	Linked
Lesotho	2004	DHS	15–49	15–59	5043	DBS	Linked
Mali	2001–02	DHS	15–49	15–59	6846	DBS	Unlinked
Niger	2002	Household survey	15–49	15–49	6056	DBS	Linked
Republic of South Africa RHRU	2003	Household survey	15–24	15–24	11904	Oral fluids	Linked
Republic of South Africa HSRC	2005	Household survey	>2 years	>2 years	15851	DBS	Linked
Rwanda	2005	DHS	15–49	15–59	10020	DBS	Linked
Senegal	2005	DHS	15–49	15–59	7524	DBS	Linked
Sierra Leone	2005	Household survey	15–49	15–49	8308	DBS	Linked
Tanzania	2004	AIS	15–49	15–49	10747	DBS	Linked
Uganda*	2004–05	AIS	15–49	15–49	16714	Venous	Linked
Zambia	2002	DHS	15–49	15–59	3807	DBS from venous draw	Unlinked
Zimbabwe	2001–02	Household survey	15–29	15–29	10744	DBS	Linked

DHS, Demographic and Health Survey (preliminary reports for Guinea, Rwanda, Senegal); DBS, dried blood spots; AIS, AIDS Indicator Survey (preliminary report for Uganda); RHRU, Reproductive Health Research Unit; HSRC, Human Sciences Research Council.
*Numbers tested; for DHS/AIS countries for the 15–49 age range, except Mali (men are 15–59).

prevalence ratio and the female:male HIV prevalence ratio for adults (except for Zimbabwe which included young people aged 15–29 only). Numerators were calculated based on the denominators and the percent HIV positive if they were not available in the reports. Denominators were based on the number eligible and the percent tested if they were not available in the reports. We also calculated the crude and weighted (by population of the country, as per the 2004 revision of the UN Population Division) median urban:rural and female:male HIV prevalence ratio for adults. For the median urban:rural ratio, all surveys were included, except the Congo survey which was limited to urban areas and the South African survey among young people conducted by the Reproductive Health Research Unit (RHRU) of the University of Witwatersrand. We finally explored the possible effect of non-response on reported HIV prevalence by assuming different relative risks for HIV infection among individual non-responders.

RESULTS

The 19 countries that have conducted national population based surveys are Burkina Faso, Burundi, Cameroon, Congo, Equatorial Guinea, Ghana, Guinea, Kenya, Lesotho, Mali, Niger, Republic of South Africa, Rwanda, Senegal, Sierra Leone, Tanzania, Uganda, Zambia, and Zimbabwe (table 1).[12–31] Most surveys have targeted the adult population (typically women aged 15–49 years and men aged 15–49 or 15–59 years) except in Zimbabwe[31] and the RHRU study in South Africa[24] where the focus was on young people (aged 15–29 and 15–24 years respectively), and the Burundi survey (including all people older than 12 years).[13] Two surveys, the South African Human Sciences Research Council (HSRC) household survey and the Uganda AIS survey also included children.[25 29] While some surveys have added HIV testing to a pre-existing standard methodology (notably the international DHS survey programme), other surveys were specifically conducted to collect information on HIV and AIDS—for example, the AIS and many of the surveys that are not part of an international survey programme. The survey in Congo[15] was limited to urban areas only.

There was large variation in the sample sizes of surveys, ranging from less than 1500 people in Equatorial Guinea to more than 15 000 in the HRSC survey in South Africa and the Uganda AIS (table 1). While one would expect larger sample sizes in countries with lower prevalence, the sample sizes were not related to the expected HIV prevalence—for example, in those countries with similar population sizes, the sample size in the high prevalence countries Zimbabwe (10 744) and Zambia (3807) was similar to the sample size in the low prevalence countries Senegal (7524) and Mali (6846). In most of the surveys the biological specimen collected for HIV testing were dried blood spots (DBS) from capillary blood, while in four surveys venous blood was drawn (in the Zambia survey DBS were prepared from the venous blood). Only the survey among young people in South Africa used oral fluids.[24] Although the first few DHS surveys in Mali in 2001 and Zambia in 2002 did not link HIV results to the sociodemographic and behavioural information, all other surveys were linked (table 1).

Household response rates were high in most countries: Burkina Faso (99.4%), Cameroon (97.3%), Congo (>95%), Ghana (98.7%), Guinea (99.2%), Kenya (96.3%), Lesotho (94.9%), Mali (97.8%), Rwanda (99.7%), Senegal (98.5%), Tanzania (98.5%), and Uganda (96.8), Zambia (98.2%), and Zimbabwe (95%). However, three surveys had household response below 90%, including those for South Africa (84.1% and 88.3% for its two surveys respectively) and Equatorial Guinea (75.4%). Not enough information was provided to derive the household response rates for the surveys in Burundi, Niger, and Sierra Leone.

At the individual level, countries that reported relevant information show a clear pattern of higher response rate among women compared to men, and in urban compared to rural areas (table 2), The overall HIV testing rate of the populations surveyed varied between the lowest values of 68.2% for women and 62.2% for men in the South African

Table 2 National population surveys: individual response rates and HIV prevalence

Results	Burkina Faso	Burundi	Cameroon	Congo	Equatorial Guinea	Ghana	Guinea	Kenya	Lesotho	Mali	Niger	Rwanda	Republic of South Africa RHRU	Republic of South Africa HSRC	Senegal	Sierra Leone	Tanzania	Uganda	Zambia	Zimbabwe
Year	2003	2002	2004	2003	2004	2003	2005	2003	2004	2001–02	2002	2005	2003	2005	2005	2005	2004	2004–05	2002	2001–02
Women																				
Tested	92.3%	NA	92.1%	NA	80.60%	89.3%	92.5%	76.3%	80.7%	85.2%	NA	97.3%	68.2%	68.3%	84.5%	NA	83.5%	88.3%	79.4%	76%
Refused	4.4%	NA	5.4%	NA	0.30%	5.7%	5.0%	14.4%	12.0%	9.0%	NA	1.1%	12.6%	30.2%	9.8%	NA	12.3%	5.8%	15.7%	12.9%
Absent	1.9%	NA	2.1%	NA	19.1%	3.3%	0.2%	6.0%	2.4%	NA	NA	1.4%	NA	1.0%	2.1%	NA	4.1%	5.1%	3.0%	NA
Interviewed	0.7%	NA	0.4%	NA	NA	1.0%	0.1%	3.1%	0.2%	NA	NA	0.2%	NA		1.3%	NA			1.1%	
Not interviewed	1.1%	NA	1.7%	NA	NA	2.3%	0.1%	2.8%	2.2%	NA	NA	1.3%	NA		0.8%	NA	4.1%	5.1%	2.0%	NA
Result missing	1.5%	NA	0.3%	NA	NA	1.7%	2.3%	3.3%	4.9%	NA	NA	0.2%	NA	0.5%	3.6%	NA	0.2%	0.7%	1.9%	NA
Men																				
Tested	85.8%	NA	89.7%	NA	69.4%	80.0%	87.8%	70.3%	68.0%	75.6%	NA	95.4%	68.2%	62.2%	75.6%	NA	77.0%	82.5%	73.3%	73.0%
Refused	6.6%	NA	5.7%	NA	1.1%	10.7%	8.7%	13.0%	16.6%	14.0%	NA	2.0%	12.6%	34.6%	15.7%	NA	13.9%	5.1%	14.9%	9.6%
Absent	4.8%	NA	4.1%	NA	29.5%	7.2%	0.4%	12.2%	7.0%	NA	NA	2.2%	NA	2.2%	3.1%	NA	8.7%	10.9%	8.1%	NA
Interviewed	1.3%	NA	0.4%	NA	NA	3.2%	0.1%	3.7%	0.3%	NA	NA	0.2%	NA		1.3%	NA			1.7%	NA
Not Interviewed	3.4%	NA	3.7%	NA	NA	4.0%	0.2%	8.5%	6.6%	NA	NA	1.9%	NA		1.9%	NA	8.7%	10.9%	6.3%	
Result missing	2.8%	NA	0.5%	NA	NA	2.2%	3.1%	4.4%	8.5%	NA	NA	0.4%	NA	1.1%	5.5%	NA	0.4%	0.7%	3.7%	NA
Adult HIV prevalence*	1.8%	3.6%	5.5%	4.2%	3.2%	2.2%	1.5%	6.7%	23.5%	1.7%	0.9%	3.0%	10.2%	16.2%	0.7%	1.5%	7.0%	7.1%	15.6%	16.5%

*Prevalence rates are usually for 15–49; Mali includes males 15–59; Burundi for 15+; South Africa RHRU for 15–24; Zimbabwe for 15–29; Congo for urban areas only.
NA, not available.

surveys to almost 97.3% for women and 95.4% for men in Rwanda. HIV testing rates were below 70% for women in South Africa, and for men in Equatorial Guinea, Lesotho, and South Africa. Not enough information was provided on testing rates for Burundi, Congo, Niger, and Sierra Leone. No specific information on absenteeism and refusal rates was available for Burundi, Congo, Mali, Niger, South Africa young people survey, Sierra Leone, and Zimbabwe. Absenteeism among women varied from 0.2% in Guinea to 6.0% in Kenya and 19.1% in Equatorial Guinea. Refusal of the HIV test among women varied from 0.3% in Equatorial Guinea to 14.4% in Kenya, 15.7% in Zambia, and 30.2% in the South African HSRC survey. Absenteeism among men was higher than among women and varied from 0.4% in Guinea to 12.2% in Kenya and 29.5% in Equatorial Guinea. Refusal of the HIV test among men varied from 1.1% in Equatorial Guinea to 16.6% in Lesotho 34.6% in the South African HSRC survey.

The results of the available national population based surveys show the extreme variation of HIV prevalence in sub-Saharan Africa (table 2). HIV prevalence among adults varied from below 1% in Niger and Senegal to 23.5% in Lesotho, reflecting a clear pattern of high HIV prevalence in Southern Africa and relatively low prevalence in West Africa.

All but two surveys found a higher HIV prevalence among urban residents compared to rural (table 3). While only one survey had an urban:rural ratio below one, the 95% confidence interval included 1 for 5 out of 18 surveys. The urban:rural prevalence ratio varied from 0.95 in South Africa and 1 in Senegal to 3.32 in Rwanda and 3.73 in neighbouring Burundi. There was much variation in the urban:rural ratio in West-Africa (ranging from 1.0 in Senegal to 3.23 in Niger). The urban:rural ratio appears higher in East Africa (1.65, 1.79, and 2.06 in Uganda, Kenya, and Tanzania respectively) than in the southernmost countries in Southern Africa (0.95 and 1.13 in the two surveys in South Africa, 1.21 in Zimbabwe, 1.33 in Lesotho). The median urban:rural ratio across all eligible surveys was 1.66 (interquartile range 1.14–2.27), while the weighted median urban:rural ratio was 1.65 (interquartile range 1.15–2.06).

All but one of the surveys found a higher HIV prevalence among women compared to men (table 4). The female:male prevalence ratio varied from 0.95 in Burkina Faso and 1.07 in Sierra Leone to 2.0 in Zimbabwe (age range 15–29), 2.11 in Guinea and 2.25 in Senegal. The 95% confidence interval included 1 for 7 out of 19 surveys. The median female:male ratio across all eligible surveys was 1.46 (interquartile range 1.24–1.8), while the weighted median female:male ratio was 1.66 (interquartile range 1.37–1.8).

Table 5 shows the results of scenarios assuming that non-responders have higher HIV infection levels than those who accepted the HIV test in the survey, with relative risks of 1.25, 1.5, and 2, for countries with sufficient information on the levels of non-response.

For countries with high response levels, the overall adjusted prevalence is not very different from the prevalence observed in the survey. For example, in Rwanda with non-response of less than 4%, even with a relative risk of 2 for non-responders, the adjusted prevalence would be only 0.1% higher than the observed, with a ratio of adjusted versus observed prevalence of 1.03. However, for countries with significant levels of non-response, the adjusted prevalence can be very different from the observed. For example, in the South Africa HSRC survey with non-response of 34%, a relative risk of 2 for non-responders results in an adjusted prevalence of more than 5% higher (at 21.6%) than the observed prevalence, with a ratio of adjusted versus observed of 1.34.

Table 3 HIV prevalence in urban and rural areas

	Number tested		% Positive		Urban:rural ratio	95% CI	
	Urban	Rural	Urban	Rural		Lower	Upper
Burkina Faso	1708	5443	3.6	1.3	2.77	1.83	3.70
Burundi*	1053	3454	9.4	2.5	3.73	2.69	4.78
Cameroon	5615	4285	6.7	4.0	1.68	1.38	1.97
Congo	3453	NA	4.2	NA	NA	NA	NA
Equatorial Guinea	791	658	3.3	3.1	1.06	0.46	1.67
Ghana	4292	4852	2.3	2.0	1.15	0.83	1.47
Guinea	2050	4328	2.4	1.0	2.40	1.43	3.37
Kenya	1495	4507	10.0	5.6	1.79	1.44	2.13
Lesotho	1142	3901	29.1	21.9	1.33	1.18	1.47
Mali	2082	4764	2.2	1.5	1.47	0.93	2.01
Niger	2019	4037	2.1	0.6	3.23	1.66	4.80
SA RHRU*	6298	5606	10.6	9.4	1.13	1.00	1.25
SA HSRC*	10467	5370	10.6	11.1	0.95	0.86	1.04
Rwanda	2286	7734	7.3	2.2	3.32	2.63	4.01
Senegal	3416	4108	0.7	0.7	1.00	0.46	1.54
Sierra Leone	2625	5683	2.1	1.3	1.62	1.06	2.17
Tanzania	3276	7471	10.9	5.3	2.06	1.77	2.34
Uganda	2864	13850	10.7	6.5	1.65	1.44	1.85
Zambia	1484	2323	23.1	10.8	2.14	1.82	2.46
Zimbabwe	NA	NA	NA	NA	1.21	NA	NA
					Median	IQR	IQR
					1.66	1.14	2.27
				Weighted	1.65	1.15	2.06

For all surveys data are for 15–49, except Mali (male age range 15–59) and Burundi (age range 12+), South Africa RHRU (15–24), South Africa HSRC (age range 2+), and Zimbabwe (15–29).
*Burundi and South Africa present additional categories besides urban and rural. For Burundi results for semi-urban areas were not included; inclusion of semi-urban areas with urban areas results in a slightly higher U:R ratio of 4.0. For South Africa, formal and informal areas were combined.
Calculated number HIV positives for Equatorial Guinea of 46 does not match the number in report of 52.
Median was calculated for all surveys in the table, except Congo and South Africa RHRU; weighted median was based on the countries population.
NA, not available; IQR, interquartile range.

DISCUSSION

Among the 44 countries in sub-Saharan Africa, 19 have already reported results from a national population based survey conducted since 2001. The results from these surveys are potentially very important as they extend our knowledge about the distribution of HIV, previously largely based on data collected among pregnant women attending antenatal clinics and small area research studies, notably to non-pregnant women, men, and rural populations.

The current review of 20 surveys suggests that the calculation of the required sample size of the surveys did not always incorporate the expected HIV prevalence in the

Table 4 HIV prevalence among female and males

	Number tested		% Positive			95% CI	
	Women	Men	Women	Men	F:M ratio	Lower	Upper
Burkina Faso	4086	3065	1.8	1.9	0.95	0.62	1.27
Burundi	2909	2660	3.8	2.6	1.46	1.03	1.89
Cameroon	5227	4672	6.8	4.1	1.66	1.37	1.94
Congo	1657	1796	4.7	3.8	1.24	0.84	1.63
Equatorial Guinea	863	586	3.4	2.9	1.17	0.48	1.86
Ghana	5097	4047	2.7	1.5	1.80	1.26	2.34
Guinea	3875	2502	1.9	0.9	2.11	1.12	3.10
Kenya	3151	2851	8.7	4.6	1.89	1.51	2.27
Lesotho	3031	2012	26.4	19.3	1.37	1.22	1.51
Mali	3854	2978	2.0	1.3	1.54	0.95	2.13
Niger	2995	2987	1.3	1.0	1.34	0.70	1.98
SA HSRC	5650	3595	20.2	11.7	1.73	1.55	1.91
Rwanda	5679	4339	3.6	2.3	1.57	1.20	1.93
Senegal	4521	3004	0.9	0.4	2.25	0.81	3.69
Sierra Leone	4812	3496	1.6	1.5	1.07	0.70	1.44
Tanzania	5753	4994	7.7	6.3	1.22	1.05	1.39
Uganda	9294	7425	8.1	5.8	1.40	1.24	1.56
Zambia	2073	1734	17.8	12.9	1.38	1.17	1.59
Zimbabwe	5111	5633	22.0	11.0	2.00	1.82	2.18
					Median	IQR	IQR
					1.46	1.24	1.8
				Weighted	1.66	1.37	1.8

For all surveys data are for 15–49, except Mali (male age range 15–59), Burundi (age range 12+) and Zimbabwe (15–29).
Number HIV positive calculated for Equatorial Guinea of 46 does not match the number in report of 52.
The weighted median was based on the countries population.
IQR, interquartile range.

Table 5 Scenarios of adult HIV prevalence assuming different risks of prevalence for the non-tested relative to those who were tested

Country	Proportion non-response	Observed HIV prevalence (%)	RR 1.25	RR 1.5	RR 2	Adjusted v observed prevalence ratio (for RR 2)
			Adjusted HIV prevalence (%)			
Burkina Faso	0.089	1.8	1.84	1.88	1.96	1.09
Burundi	NA					
Cameroon	0.086	5.5	5.62	5.74	5.97	1.09
Congo	NA					
Equatorial Guinea	0.250	3.2	3.40	3.60	4.00	1.25
Ghana	0.135	2.2	2.27	2.35	2.50	1.14
Guinea	0.072	1.5	1.53	1.55	1.61	1.07
Kenya	0.228	6.7	7.08	7.46	8.23	1.23
Lesotho	0.185	23.5	24.59	25.67	27.85	1.19
Mali	0.196	1.7	1.78	1.87	2.03	1.20
Niger	NA					
Rwanda	0.034	3.0	3.03	3.05	3.10	1.03
South Africa RHRU	0.318	10.2	11.01	11.82	13.44	1.32
South Africa HSRC	0.336	16.2	17.56	18.92	21.64	1.34
Senegal	0.154	0.7	0.73	0.75	0.81	1.15
Sierra Leone	NA					
Tanzania	0.130	7.0	7.23	7.46	7.91	1.13
Uganda	0.055	7.1	7.20	7.30	7.49	1.06
Zambia	0.209	15.6	16.42	17.23	18.86	1.21
Zimbabwe	0.255	16.5	17.55	18.60	20.71	1.26

The proportion non-response was calculated as the sum of the proportion absent and the proportion refusing the HIV test.
RR, relative risk of HIV infection among non-responders, compared to those who were tested for HIV infection in the survey.
NA, not available.

country. Relatively small sample sizes in low prevalence countries such as Burkina Faso (7515 for 1.8%), Guinea (6377 for 1.5%), Senegal (7524 for 0.7%), Mali (6846 for 1.7%), and Niger (6056 for 0.9%) imply large confidence intervals around the prevalence results. Unfortunately, most surveys have not presented confidence bounds around the point prevalence results from the survey, thereby failing to convey the uncertainty in the prevalence estimate related to sampling error. Future surveys should add this information to the survey report.

Besides sampling error and possible laboratory error (the latter has not been addressed in our review), HIV prevalence surveys may suffer from bias introduced by non-response, as non-responders may have different levels of HIV infection compared to those that participated and accepted an HIV test in the survey.[11 32] While people who refuse to take an HIV test in a survey may have higher levels of HIV infection than those who accept to take the test,[33] there is also evidence to suggest that absence from a household is associated with increased HIV prevalence. People who travel and families affected by labour migration have higher HIV prevalence rates than others.[32–36] Short term mobility (traders, business men, and people in search of work) may also be important, and people making frequent short trips may not be available during the time the survey team visits the household. In the current review, three surveys had poor household response and a further three did not contain specific information on the household response. Eleven out of the 20 surveys had detailed information on individual non-response. UNAIDS and WHO have recently published guidance on how to analyse the effect of non-responders' characteristics on prevalence.[37] However, none of the survey reports has included adjusted estimates of HIV prevalence based on this type of analysis, although a separate report with an in-depth analysis is available for Ghana[33] and Kenya.[38] In Kenya the sociodemographic characteristics of both respondents and non-respondents were similar and the analysis concluded that there was no evidence to suggest that non-responders have higher HIV prevalence.[38] On the other hand in the Ghana survey non-tested men were somewhat more likely to be infected (1.9%) than men who were tested (1.6%) but there was no difference for women. The in-depth analysis concluded that mobility among men was a significant risk factor for HIV infection.[33]

Simple scenarios assuming different relative risks for HIV infection among non-responders suggest that, with the observed levels of individual non-response in the available surveys, overall HIV prevalence would be 1.03 to 1.34 times higher than the observed prevalence, if non-responders have twice the prevalence of those who fully participated in the survey. An analysis of bias due to non-response should be included in future survey analysis plans and reports. While the current design of HIV prevalence surveys can address bias introduced by test refusers (because the survey collects information on their characteristics, including age, sex, and residence, and their behaviours), insufficient information is being collected regarding absentees to allow a similar analysis for absentees. Future surveys should seek to collect more information about characteristics and behaviours of absentees, including information related to their mobility, to be used in this analysis.

Due to the distribution of HIV infection in concentrated epidemics, population based surveys are not appropriate for estimating prevalence levels in countries with such epidemics, mainly because of the difficulty for household surveys to capture those at highest risk of HIV, including sex workers and their clients, injecting drug users, and men who have sex with men.[37] In countries with concentrated epidemics these population groups constitute a large proportion of the epidemic. Population based surveys are therefore likely to underestimate HIV prevalence in these countries. In the current set of countries with population based surveys, countries with relatively low prevalence, including Burkina Faso, Guinea, Mali, Niger, Senegal, and Sierra Leone, may also suffer from this bias to some extent.

Although the HIV prevalence results from national surveys may suffer from bias due to non-response, this is unlikely to explain the important differences that have been found in

many countries between the prevalence measured in these surveys and the prevalence estimates based on antenatal clinic surveillance.[7 9 11 39] Small area studies comparing the HIV prevalence among pregnant women attending antenatal clinics to the HIV prevalence among the general population have shown that HIV prevalence among pregnant women is a fairly good indicator of HIV prevalence of both sexes combined in the community.[40] Typically, HIV prevalence in the female population, aged 15–49 years, tends to be a little higher than prevalence among ANC attendees, while male prevalence is somewhat lower. Recent comparisons with surveys show that in some countries prevalence among pregnant women is higher than that among adults in the community,[38] while in others it is confirmed to be similar.[33] The major reason for the discrepancy in prevalence results between the two sources appears to be the partial geographical coverage of the antenatal clinics that constitute the sentinel surveillance system. In particular, remote rural areas were often poorly covered by ANC surveillance in countries in which prevalence estimates have been revised.[39]

Taken together, ANC sentinel surveillance and population based surveys can provide complementary information, thereby providing a clear picture of the level, trends, and distribution of HIV infection. For countries with both sources of data, it is recommended that in-depth analyses be done on each dataset, as well as a joint analysis of both data sources.[37] As discussed in other papers in this supplement, the information from surveys, adjusted as appropriate, can be used in software tools for the analysis of national AIDS epidemics.[41 42]

Urban:rural and female:male for individual countries may not be stable measures, especially in countries with low prevalence and/or surveys with small sample sizes. For example, in Senegal with the highest female:male ratio at 2.25, one cannot reasonably exclude the possibility that more men are infected than women, as the 95% confidence interval includes 1. In these circumstances these measures should be interpreted with caution, and it may be more appropriate for countries with low HIV prevalence to apply the more robust median across all surveys. The combined set of 20 surveys clearly shows differences in the prevalence between urban and rural areas, with a median urban:rural ratio of 1.7 across all surveys, although it appears lower in southern Africa. Although definitions of urban and rural areas are not standardised across countries, and the urban:rural ratio may not be a comparable measure from one country to another, it is recommended that the 1.7 median urban:rural ratio be considered in countries that have not yet done a national population based survey. The current set of surveys also results in a median female:male ratio of 1.5. This median female:male prevalence ratio has been incorporated in the Spectrum software as default value, updating the previously used value of 1.3.[42]

In conclusion, national HIV prevalence surveys with good participation rates are a very useful addition to the knowledge base on the level and distribution of HIV infection in sub-Saharan Africa. The information from the surveys has already been used to refine national HIV and AIDS estimates for the countries with surveys and provides default values to the methods used in the HIV estimation process. Insights from this set of surveys are also being used to inform countries without surveys. Future surveys should seek to achieve high levels of participation, collect more information on absentees, and routinely report an adjusted HIV prevalence based on an analysis of possible bias introduced by non-response, as well as reflect the uncertainty about the survey's HIV prevalence estimate.

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AUTHORS' CONTRIBUTIONS

The three authors have contributed equally to the conceptualisation of the paper, the analysis of the data, and to writing the paper.

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