

HIV Prevalence Comparison Between Antenatal Sentinel Surveillance and Demographic and Health Survey in Rwanda[§]

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Abstract: *Objective:* To compare HIV prevalence from antenatal surveillance to that of the demographic and health survey (DHS), and to identify factors determining the difference of HIV prevalence between women recruited in these two surveys in Rwanda in 2005.

Methods: Comparative cross-sectional study of HIV prevalence and socio-demographic factors collected by the antenatal survey in 13,745 pregnant women, seen in 30 health centres located throughout the country and those collected by the DHS among 5641 women, aged 15-49 years living in households located throughout the country. Log-binomial regression and direct standardization were used to estimate and compare HIV prevalence between the two surveys.

Results: HIV prevalence in the antenatal survey was slightly higher than that in DHS women (4.1% versus 3.6% $p=0.103$). Socio-demographic characteristics were differently distributed between the two populations. Whereas, 59%, 93%, 53% of pregnant women were aged 20-29 years, married or cohabiting and living in rural areas respectively, the corresponding proportions among DHS women were 35%, 48% and 83% ($p<0.001$). Simultaneous standardization of antenatal prevalence according to the distribution of socio-demographic characteristics in the DHS gave an overall HIV prevalence estimate of 3.6%, similar to the prevalence measured among DHS women.

Conclusions: HIV prevalence in the antenatal survey overestimated that among women of the general population in Rwanda in 2005. This overestimation could be corrected by standardization of antenatal prevalence according to the distribution of age, geographical area, marital status, parity, and education, in the general population.

Keywords: Rwanda, HIV prevalence, sentinel surveillance, demographic and health survey.

INTRODUCTION

For the last two decades sentinel surveillance was largely used as the main indicator for monitoring the progress of the HIV epidemic at the national level [1, 2].

However some studies showed that HIV prevalence among pregnant women overestimate that in women of the general population [3, 4], whereas other showed opposite results [5, 6].

Thus, national and global HIV prevalence and AIDS mortality estimates derived from HIV sentinel surveillance

have been criticised because the sentinel population is often non representative of the general population.

Indeed, the poor functioning of HIV sentinel surveillance system in some sub Saharan African countries with generalized epidemics, among them Rwanda, explain in part why global HIV/AIDS estimates at the end of 2002 were higher than those reported in 2003 [7-9]; whereas UNAIDS and WHO revised the global estimate of the number of HIV-infected people from 39,5 million in 2006 to 33,2 million in 2007 partly for the same reason [10].

Since 2001 some low and middle-income countries have conducted population-based household surveys, the demographic and health surveys (DHS) which included HIV testing [11]. WHO/UNAIDS and some authors recommend that the countries in which these surveys are implemented use HIV national estimates to calibrate antenatal data, and use the combined national and antenatal data to estimate prevalence among the general population [12-14].

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The first DHS including HIV testing was carried out in 2005 in Rwanda, whereas the HIV antenatal surveillance was improved in 2002 to ensure national coverage.

We compared HIV prevalence from these two sources of data as collected in 2005, in order to validate the new antenatal surveillance program.

DATA AND METHODS

We obtained HIV data from the third DHS conducted by Macro International and the Rwanda National Institute of Statistics in 2005 [15] and from the ANC surveillance from Rwanda Treatment and Research Aids Center [16] collected the same year.

Demographic and Health Survey

In 2005, Rwanda organized its third DHS which was its first that included HIV testing. A national representative sample of 10 644 households was selected using two-stage cluster sampling based on the list of the 2002 General Population and Housing Census.

All men and women of every second selected household were eligible for HIV testing. After informed consent blood samples were collected from all eligible men and women who volunteered to be tested in these households.

A laboratory technician collected capillary blood from finger prick on a filter paper, testing for HIV antibodies was performed at the National Reference Laboratory (NRL) in Kigali, using ELISA tests [15].

A face to face interview covered socio-demographic characteristics and other health issues including HIV related behaviour. Questionnaires were translated from English or French to local language (Kinyarwanda), and a pre-test was organized before the survey to validate them.

The Sentinel Surveillance System

The 2005 surveillance included 30 sites out of 372 health centers located all over the country: 2 sites in Kigali (Capital), 12 sites in other urban areas, and 16 sites in rural areas.

The sentinel sites were selected according to the number of pregnant women registered for their first antenatal visit (at least 80 new pregnant women per month), the availability of at least one laboratory technician and one midwife on site, the geographical accessibility of the site and the ability to accomplish the surveillance activities on a regular basis.

For all pregnant women attending ANC, a venous blood sample was taken for syphilis testing, and sera were anonymously tested for HIV, using the same laboratory algorithm as that used for the DHS specimens. For each woman, information was collected on socio-demographic factors.

For both DHS and ANC surveillance specimens, testing was done without any knowledge of the socio-demographic characteristics of participants. Socio-demographic and serologic data were matched by a unique survey code after completion of all serological testing.

Statistical Analyses

The SAS software (SAS Institute Inc., Version 9.1.3, Cary, NC, USA) was used for statistical analyses.

To make comparison between the two populations, we firstly merged the ANC and women DHS data set keeping the common variables: socio demographic (age, geographic area, schooling, marital status and number of children); and HIV status. We then created a new dichotomous variable comparison coded 1 for ANC population and 0 for DHS women.

We compared the distribution of socio-demographic characteristics of ANC and DHS women using the chi-square test. In order to determine which characteristics caused differences in HIV prevalence between the two populations we also carried out univariate and multivariate comparisons considering HIV status as the dependent variable and socio-demographic characteristics as the independent variables. The model included also the comparison variable. The ratio of HIV prevalence from DHS women to ANC women with 95% confidence intervals (CI) was used as the measure of association, whereas statistical testing was based on Wald chi-square tests from log binomial regression outputs. The proc genmod SAS procedure was used for this step.

To correct ANC bias and to estimate the overall HIV prevalence among women in the general population from the ANC data, we applied a direct standardization of HIV prevalence among ANC attendees according to the distribution of all socio-demographic characteristics common to both databases. We used proc freq SAS procedure for this analysis.

Ethical Considerations

For the DHS, an informed consent form was read to the eligible subjects or to parents/tutors of teenagers (aged 15 to 18 years); when the parent or tutor of a teenager agreed to the test, the form was read to the teenager to obtain his/her own consent to the HIV test.

HIV testing was entirely anonymous in the DHS and the study protocol was approved by ORC Macro's Internal Review Board and the National Ethics Committee in Rwanda. The testing protocol followed in the ANC survey is based also on unlinked anonymous testing of HIV, as recommended by WHO since 1989 [17]. Furthermore, the ANC survey protocol was approved by the Centers of Disease Control and Prevention (CDC, Atlanta, USA) ethics committee.

We received authorization to access the data sets from the authorities of the Rwandan National Institute of Statistics and the Rwanda Treatment and Research Aids Center

In addition, we received ethical exemption from Université Laval ethics committee because our research concerned entirely anonymised data.

RESULTS

A total of 13 745 ANC attendees and 5 641 women recruited in the DHS were included in the study: 95.2% of all

new pregnant women registered for antenatal consultation in 30 sentinel sites participated in the 2005 ANC survey [16], whereas 97.3% of eligible women of the general population accepted to give a blood sample for HIV testing [15].

Characteristics of both populations are presented in Table 1. While the proportions of women living in the capital city were similar in both populations: 8% for DHS population versus 7% for ANC population, in other urban areas the proportion of DHS women was 9% compared with 40% for the ANC population. The respective proportions for rural areas were 83% versus 53% (p<0.001). Median age was similar in both populations (26 years): but younger and older women (15-19; 40-49 years) were more represented in the DHS than in the ANC population, whereas women aged between 20 to 39 years were more represented among pregnant women (p<0.001).

Single women and women living alone (including separated, divorced and widowed) were much more represented in the DHS than in the ANC population (p<0.001).

There are more women in the general population than among pregnant women who have high school level or more, particularly in the Capital city (38% versus 20%).

Overall HIV prevalence among DHS women was 3.6% (95% CI: 3.1-4.1%), lower than that estimated in ANC attendees, 4.1% (95% CI: 3.8-4.5%).

Table 2 shows HIV prevalence in the two surveys stratified by geographical areas. For both, estimates of HIV prevalence were very different between areas; the highest prevalence is noted in the Capital city, the lowest in rural areas. In the Capital, HIV prevalence estimated was lower in

Table 1. Socio Demographic Characteristics of Demographic and Health Survey (DHS) and Sentinel Surveillance (ANC) Women by Geographic Area

Characteristics	The Capital City (Kigali)		Other Urban Areas		Rural Areas		Total*	
	No (%)		No (%)		No (%)		No (%)	No (%)
	DHS Women 437 (8)	ANC Women 1008 (7)	DHS Women 504 (9)	ANC Women 5473 (40)	DHS Women 4700 (83)	ANC Women 7264 (53)	DHS Women 5641	ANC Women 13745
Median age	25	24	26	27	27	27	26	26
Interquartile range	19-32	21-29	20-35	23-32	20-36	23-32	20-36	23-32
Age group (year)								
15-19	112 (26)	136 (14)	121 (24)	328 (4)	1085 (23)	315 (4)	1318 (23)	779 (6)
20-24	104 (24)	396 (39)	98 (20)	1673 (31)	936 (20)	2300 (32)	1138 (20)	4369 (32)
25-29	84 (19)	252 (25)	75 (15)	1474 (27)	668 (14)	1924 (27)	827 (15)	3650 (27)
30-34	59 (13)	139 (14)	81 (16)	1066 (20)	665 (14)	1357 (19)	805 (14)	2562 (19)
35-39	35 (8)	69 (6)	52 (10)	615 (11)	448 (10)	858 (12)	535 (10)	1535 (11)
40-49	43 (10)	21 (2)	75 (15)	270 (5)	897 (19)	437(6)	1016 (18)	728 (5)
Marital status								
Single	224 (51)	115 (11)	227 (45)	335 (6)	1728 (37)	179 (2)	2179 (39)	629 (5)
Legally married	82 (19)	235 (23)	146 (29)	2435 (45)	1383 (29)	3402 (47)	1611 (28)	6072 (44)
Cohabitation	58 (13)	623 (63)	69 (14)	2599 (47)	976 (21)	3555 (49)	1103 (20)	6777 (49)
Widowed, separated	67(15)	34(3)	59(12)	70(1)	561(12)	76(1)	688(12)	180(1)
Divorced	5 (1)	1 (0)	1 (0)	25 (0)	50 (1)	42 (1)	57 (1)	68 (0)
Education level								
None/Primary	272 (62)	795 (80)	388 (77)	495 (91)	4423 (94)	7015 (97)	5083 (90)	12761 (93)
Secondary/Higher	165 (38)	200 (20)	116 (23)	483 (9)	277 (6)	213 (3)	558 (10)	896 (7)
Number of children								
0	203 (47)	337 (34)	207 (41)	1148 (21)	1728 (37)	1426 (20)	2138 (38)	2911 (22)
1	54 (12)	257 (25)	48 (9)	980 (18)	434 (9)	1194 (17)	536 (10)	2431 (18)
2-3	88 (20)	241 (24)	93 (19)	1501 (28)	842 (18)	1980 (27)	1023 (18)	3722 (27)
4-5	60 (14)	119 (12)	79 (16)	1033 (19)	736 (16)	1465 (20)	875 (15)	2617 (19)

All chi-square tests comparing the distribution of socio-demographic characteristics of ANC women to those of DHS female were statistically different; (all p-value < 0.0001).

Table 2. HIV Prevalence Among DHS and ANC Women by Geographic Area

Characteristics	The Capital City (Kigali)		Other Urban Areas		Rural areas	
	HIV+ve (%)		HIV+ve (%)		HIV+ve (%)	
	DHS Women N=437 (8)	ANC Women N=1008 (7)	DHS Women N=504 (9)	ANC Women N=5473(40)	DHS Women N=4700 (83)	ANC Women N=7264 (53)
Overall prevalence	42 (9.5)	129(12.8)	38(7.7)	275(5)	123(2.6)	162(2.2)
Prevalence standardized ^a	9.5	13.2	7.7	5.6	2.6	2.5
Age group (year)						
15-19	1(1.6)	11(8.1)	1(0.6)	13(3.9)	6(0.6)	5(1.5)
20-24	10(10.13)	44(11.1)	4(4.7)	64(3.8)	13(1.5)	45(1.9)
25-29	4(5.2)	37(14.7)	7(9.8)	71(4.8)	15(2.4)	36(1.8)
30-34	8(14.1)	26(18.7)	8(10.1)	72(6.7)	30(4.6)	50(3.6)
35-39	9(25.6)	10(16.1)	8(16.5)	44(7.1)	19(4.2)	17(1.9)
40-49	7(17.5)	1(4.7)	9(12.3)	9(3.3)	37(4.1)	8(1.8)
X²(df=5)	25.41 (p=0.001*)	10.67 (p=0.06)	18.81 (p=0.002*)	20.06 (p=0.001*)	46.03 (p<0.001*)	16.18 (p=0.006*)
Marital status						
Single	10(4.7)	21(18.2)	5(2.3)	18(5.3)	18(1.1)	8(4.4)
Married	4(5.8)	17(7.2)	6(4.5)	76(3.1)	29(2.1)	60(1.7)
Cohabitation	6(10.6)	74(11.8)	10(15.5)	163 (6.2)	18(1.9)	89(2.5)
Separated/Divorced/ Widowed	20(27.8)	17(48.6)	16(26.6)	16 (16.8)	56(9.2)	5(4.2)
X²(df=3)	35.62 (p<0.001*)	50.20 (p<0.001*)	47.92 (p<0.001*)	55.12 (p<0.001*)	122.52 (p<0.001*)	10.89 (p=0.012*)
Education level						
No education/Primary	26(9.8)	108(13.6)	29(7.5)	238(4.8)	110(2.5)	150(2.1)
Secondary/Higher	15(9.1)	19(9.5)	9(8.4)	32(6.6)	11(4.3)	11(5.1)
X²(df=1)	0.05 (p=0.813)	2.3 (p=0.12)	0.09 (p=0.757)	3.08 (p=0.07)	3.18 (p=0.074)	8.69 (p=0.003*)
Number of children						
0	9(4.5)	26(7.7)	4(1.9)	36(3.1)	17(1.0)	21(1.4)
1	6(11.7)	40(15.6)	4(9.2)	49(5)	16(3.8)	29(2.4)
2-3	12(14.4)	37(13.4)	14(15.1)	89(5.9)	39(4.7)	49(2.5)
4-5	10(18.2)	19(15.9)	9(11.4)	66(6.3)	21(2.9)	45(3.1)
6+	2(8.5)	5(10.6)	7(9.6)	23(3.2)	26(2.8)	16(1.4)
X²(df=4)	14 (p=0.007*)	12.31 (p=0.01*)	18.75 (p=0.009*)	20.01 (p=0.005*)	35.54 (p<0.001*)	12.75 (p=0.012*)

^aHIV prevalence among pregnant women in each geographical area directly standardised to the distribution of all variables (age, marital status, education, parity) of DHS women. df: Degree of freedom.

*Statistically significant.

DHS women than in ANC attendees: 9.5% (95% CI: 6.9-12.4) versus 12.8% (95% CI: 10.7-14.9). In other urban areas, the prevalence estimated among ANC attendees was lower than in the DHS women: 5% (95% CI: 4.4-5.6%) versus 7.7% (95% CI: 5.2-9.9) whereas in rural areas, the DHS prevalence estimate was 2.2% (95% CI: 1.9-2.7) compared to 2.6% (95 CI: 2.2-3.1) for ANC prevalence.

Standardization based on all variables (age, area, marital status, education, parity) into each area results in an overall HIV prevalence of 13.3% in ANC women living in the

capital city, 5.6% for those in other urban areas and 2.5% for ANC women living in rural area.

Table 3 shows the comparison between HIV prevalence in the two populations. ANC surveillance slightly overestimated the overall HIV prevalence in DHS women. The overall crude prevalence ratio (PR) was 1.13 (95% CI: 0.97-1.33).

Comparison of HIV prevalence by each category of socio-demographic characteristics reveals that HIV prevalence was higher among women aged 15-24 years in

Table 3. Comparison of HIV Prevalence in ANC and DHS Women

	ANC Women HIV+ve (n)	DHS Women HIV+ve % (n)	Crude Prevalence Ratio Comparing ANC and DHS Women (95%CI)	p	Adjusted Prevalence Ratio comparing ANC and DHS Women** (95%CI)	p
Overall	4.1(563)	3.6(203)	1.13 [0.97-1.33]	0.103		
Age standardised^a	3.9	3.6				
Age & area^b	3.1	3.6				
Age & area & marital status & education & parity	3.6	3.6				
Age group (year):						
15-24	3.5(182)	1.5(38)	2.30 [1.62-3.25]	<0.0001*	2.29 [1.51-3.46]	<0.0001*
25-29	3.9(144)	3.3(27)	1.18 [0.79-1.77]	0.3987	1.56 [0.96-2.53]	0.0674
30-34	5.7(148)	5.9(47)	0.97 [0.71-1.34]	0.8980	1.46 [0.95-2.27]	0.0836
35-49	3.9(89)	5.9 (91)	0.67 [0.50-0.89]	0.0064*	1.20 [0.76-1.88]	0.4296
Area						
Rural	2.2(162)	2.6(123)	0.85 [0.67-1.07]	0.1795	1.50 [1.04-2.18]	0.0294*
Other urban areas	5(274)	7.7(38)	0.64 [0.46-0.89]	0.0085*	1.09 [0.72-1.64]	0.6616
Capital	12.8(129)	9.5(42)	1.34 [0.96-1.86]	0.0814	2.42 [1.61-3.64]	<0.0001*
Marital status:						
Legally married	2.5(153)	2.5(41)	0.99 [0.71-1.39]	0.9631	1.40 [0.91-2.16]	0.1243
Cohabitation	4.8(326)	3.2(36)	1.49 [1.06-2.10]	0.0207*	1.84 [1.17-2.90]	0.0077*
Living alone (separated, divorced, widowed, single)	9.7 (85)	4.3(127)	2.23 [1.71-2.90]	<0.0001*	1.54 [1.10-2.15]	0.0104*
Parity						
Nulliparous	2.8(83)	1.4(30)	1.96 [1.30-2.96]	0.0012	2.12 [1.23-3.63]	0.0062*
Parity 1+	4.3(467)	4.9(170)	0.89 [0.75-1.05]	0.1815	1.18 [0.91-1.54]	0.1988
Education						
None/Primary	3.8(429)	3.3(166)	1.18 [0.99-1.40]	0.0548	1.56 [1.15-2.12]	0.0040*
Secondary/higher	6.9(62)	6.6(36)	1.05 [0.71-1.56]	0.7903	1.60 [1.03-2.50]	0.0351*

ANC: Antenatal clinics.

CI: Confidence interval.

^aANC prevalence directly standardised to the distribution of DHS women age (using 6 age groups:15-19; 20-24; 25-29; 30-34; 35-39; 40-49).^bANC prevalence directly standardised simultaneously to age (age group above) distribution of DHS women by area (capital city, other urban areas, rural areas).

*Statistically significant.

^cANC prevalence directly standardised simultaneously to age, area, marital status, education, parity distribution of DHS women.

**Adjusted for all variables.

the ANC survey compared to the DHS (adjusted prevalence ratio (APR): 2.29 p=0.001).

According to the area of residence, APR was higher among ANC women than in DHS women, specifically in rural areas and in the Capital city (p=0.029 and p< 0.0001 respectively).

Concerning marital status, results show that ANC attendees who were not legally married were more often HIV-positive than DHS women with the same marital status (p=0.0077 for cohabiting women and p=0.0104 for women living alone, respectively).

Only standardization based on all variables gave an overall HIV prevalence of 3.6% in ANC women, similar to that measured in DHS population.

DISCUSSION

The results of this study show that in 2005, HIV sentinel surveillance among pregnant women slightly overestimated overall HIV prevalence seen in DHS women (PR= 1.13; p=0.103).

Opposite results were showed in some sub Saharan Africa countries [5, 6, 18], whereas similar results were demonstrated in 1998 in Ethiopia [19] and in 2005 in South Africa [3]. The factors presented by the authors of these two studies as explanations of the overestimation of ANC-based estimates do not seem to be applicable to the context of Rwanda. Indeed in the Ethiopian study, the selection bias related to the high-risk women who refused the test in the population based-survey appeared to explain the observed differences [18], whereas the highest use of modern

contraception was associated with the ANC overestimation in the South Africa study [3]. Related to these two factors, Rwanda DHS data showed a 97.3% participation rate for HIV testing among women, whereas contraceptive use among sexually active women was 9.6% in the same study [15]. Comparison made between HIV prevalence reported from a household survey and an antenatal survey conducted in Rwanda in 1997 and in 1998, respectively, showed that HIV prevalence among women of the general population was higher than among ANC women (11.3% versus 9.5% respectively) [20].

The results of surveys conducted early after the 1994 genocide in Rwanda need to be interpreted cautiously, due to changes that occurred in the population during this period (mortality and displacement), the consequences of the destruction of health services infrastructure on the quality of the data, and the representativeness of sentinel surveillance system.

In fact, when observing HIV estimates reported in 1997-98 and those reported a few years later in 2000, when the country was stabilized, health system and other infrastructures strengthened (i.e. expansion of national sentinel surveillance in 2002), HIV prevalence estimated by sentinel surveillance dropped from 9.5% to 5.2% [21] whereas that estimated in the general population dropped from 11.3% to 3.6% according to the 2005 demographic and health survey [15]

Socio-demographic characteristics differed between both populations, while being associated with HIV prevalence, thus leading to the observed differences in HIV prevalence between ANC women and those from the general population. The main difference was the distribution according to the type of geographic area. Except in the Capital city where the proportion of women was almost similar for both populations (Table 1), in other urban areas, pregnant women were more represented than women of the general population, the reverse situation being observed in rural areas. The over representation of pregnant women in other urban areas is a result of a misclassification of the rural/urban status of pregnant women enrolled in urban sites outside the capital city: in fact, the sites known as urban (out of the Capital) included a small zone which could have all typical characteristics of an urban setting (out of the Capital) whereas the rest of its catchment refers to a rural area. Actually the sites located in other urban areas received more pregnant women from their rural catchment than those from their urban catchment (the similarity of characteristics between ANC women of other urban and rural areas can be seen in Table 1) This situation leads to an underestimation of the actual HIV prevalence among ANC women living in urban areas other than the Capital city. We suggest to add on the variable list collected in the ANC survey, the administrative sector where the pregnant women comes from; that could help to identify if the pregnant women comes from an urban or rural zone of the sentinel site.

The overestimation in the capital city (adjusted prevalence ratio: 2.42 $p=0.0001$), could result from a selection bias due to the location of sentinel sites in this area. In fact, the two sentinel facilities are located in areas where stay most of sex workers and truck drivers from Dar Es Salaam and Mombasa (Bilyogo and Gikondo sites), two of

the main high-risk groups for HIV infection in sub-Saharan Africa [22-27]. These health facilities could attract a large number of pregnant women from these high-risk groups (sex workers and women having relationships with truck drivers).

A simultaneous standardization of the ANC results for the DHS distribution of all socio-demographic factors common to the two surveys resulted in a 3.6% overall prevalence estimated for women in the general population from the ANC population data; when we applied this standardization into each geographic area, it resulted in an overestimation in the Capital city and an underestimation in the other urban areas (Table 2).

Despite the differences seen between HIV prevalence measured by the two surveys, sentinel surveillance was a relatively good proxy to estimate *overall* HIV prevalence among women of reproductive age in Rwanda in 2005. That is partly a result of the extension of sentinel sites established in 2002 which added more rural sites; this reduced the selection bias due to the limit of geographical coverage of sentinel sites. This kind of selection bias was the main bias related to the first sentinel surveillance systems in Africa, which were characterized by an over representation of urban sites [28].

Compared with overall adult HIV prevalence (among both women and men) Rwanda sentinel surveillance overestimates HIV prevalence in the general population (4.1% versus 3%) [15]. This situation is not only for Rwanda; despite improvements and expansion of surveillance systems in recent years [11], antenatal surveillance continues to overestimate adult prevalence in many countries with generalised epidemics [14].

In order to obtain accurate national-level estimates of HIV prevalence from sentinel data, UNAIDS made modifications to different versions of the UNAIDS Estimation and Projection Package (EPP) [29, 30]; however, because of difference in prevalence of HIV between men and women and the lack of male data in current antenatal surveillance, estimates of HIV prevalence from antenatal surveillance will suffer from bias related to the HIV male – to- female ratio. In fact, the proportion of women among HIV cases increases over time, especially in sub-Saharan Africa [31]. In their recent work Lowndes *et al.* showed that in nine West African countries, HIV prevalence was almost always higher among females than males for all marital statuses [32]; also the situation in Rwanda shows that since the beginning of the HIV epidemic, women were more infected than men. The female-to-male ratio was 1.4 [15.4 (HIV prevalence among women):10.8 (HIV prevalence among men)] in 1986 [19] and 1.6 in the 2005 DHS [15]. Thus, the adjustment factor and calibrating parameter applied to antenatal surveillance data should consider the influence of the sex ratio of HIV infection which changes overtime with the stage of the epidemic.

Furthermore, in future, it will be necessary to investigate the potential bias between antenatal and population-based surveys due to the effects of anti-retroviral therapy (ART) on fertility of HIV positive women who consider becoming pregnant, and the impact of family planning services offered to HIV-infected women who do not wish to become pregnant. We do not think that these effects were present at

the time of our study, as Rwanda started a significant ART program in 2003, only two years before data collection of this study.

In conclusion, our results show that antenatal surveillance overestimated HIV prevalence among women of the general population in Rwanda. This overestimation is due to the difference of distribution of socio-demographic characteristics associated with HIV between antenatal and DHS populations.

Antenatal surveys remain a useful tool to monitor the epidemic, but their results need to be adjusted to better reflect the prevalence in the general adult population of women, while inference from such data to the global prevalence among the total adult population of both sexes may remain difficult, with the temporal changes in the male-to-female ratio in HIV prevalence. Consequently, DHS must also be included in the package of HIV surveillance activities (although on a less regular basis than ANC surveillance), especially to provide information on the HIV epidemiology among men. Considering the impact of highly active anti-retroviral therapy era on HIV-related mortality, incidence studies are needed to estimate the magnitude of new cases of HIV and monitor the trends of the epidemic.

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