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Kévin Jean, Adrian Puren, Ewalde Cutler, Beverley Singh, Julie Bouscaillou, et al.. Level of viral suppression and the cascade of HIV care in a South-African semi-urban setting in 2012. AIDS. Official journal of the international AIDS Society, 2016, 30 (13), pp.2107-2116. 10.1097/QAD.0000000000001155 . hal-01350981

HAL Id: hal-01350981

<https://hal.science/hal-01350981>

Submitted on 3 Aug 2016

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QAD

DOI: 10.1097/QAD.0000000000001155

Title (84 characters)

Level of viral suppression and the cascade of HIV care in a South-African semi-urban setting in 2012

Short title: Cascade of HIV care in South Africa

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Word count: 3465

Abstract (249 words)

Objective: In 2012, seven years after the introduction of ART in the South-African township of Orange Farm, we measured the proportion of HIV-positive people who were virally suppressed, especially among high risk groups (women 18-29y and men 25-34y).

Design: A community-based cross-sectional representative survey was conducted among 3293 men and 3473 women.

Methods: Study procedures included a face-to-face interview and collection of blood samples that were tested for HIV, 11 antiretroviral drugs (ARVs) and HIV-Viral Load (VL).

Results: HIV prevalence was 17.0%[95%CI: 15.7-18.3%] among men and 30.1%[28.5-31.6%] among women. Overall, 59.1%[57.4-60.8%] of men and 79.5%[78.2-80.9%] of women had previously been tested for HIV. When controlling for age, circumcised men were more likely to have been tested compared to uncircumcised men (66.1% vs 53.6%; $p<0.001$). Among HIV+, 21.0%[17.7-24.6%] of men and 30.5%[27.7-33.3%] of women tested positive for on or more ARV. Using basic calculations we estimated that, between 2005 and 2012, ART programs prevented between 46%-63% of AIDS-related deaths in the community. Among ARV+, 91.9%[88.7-94.3%] had viral suppression ($VL<400$ copies/mL). The proportion of viral suppression among HIV+ was 27.0%[24.3-29.9%] among women and 17.5%[14.4-20.9%] among men. These proportions were lower among the high risk groups: 15.6%[12.1-19.7%] among women and 8.4%[5.0-13.1%] among men.

Conclusion: In Orange Farm, between 2005 and 2012, ART programs were sub-optimal and, among those living with HIV, the proportion with viral suppression was still low, especially among the young age groups. However, our study showed that in reality ARVs are highly effective in viral suppression at an individual level.

Keywords

Africa; HIV; ARV; Viral load; Male circumcision; HIV testing; Cascade of HIV care.

ACCEPTED

Introduction

Antiretroviral treatment (ART) has been rapidly scaled-up in sub-Saharan Africa in the last decade. It was initially used to prevent HIV-related deaths, as well as for the prevention of mother-to-child transmission (PMTCT) [1,2]. More recently, different studies highlighted the preventive effect of ART on onward sexual transmission [3–5], which has led the World Health Organization (WHO) to recommend the use of ART for both individual and collective benefits [6]. However, in order to have an impact on HIV incidence at a population-level, the coverage of those receiving treatment and having a suppressed Viral Load (VL) (as a proportion of all people living with HIV) should be high [7,8]. Particularly, ART coverage and viral suppression should be high among the age groups representing the highest HIV incidence levels. Recently, the Joint United Nations Programme on HIV/AIDS (UNAIDS) proposed ambitious treatment targets for 2020, suggesting that 90% of all HIV-infected people should be diagnosed by 2020, 90% of all HIV-diagnosed people should be receiving sustained ART, and 90% of people receiving ART should be virally suppressed [9]. Meeting this “90-90-90” target would result in viral load suppression among 73% of all people living with HIV and would contribute significantly to the reduction of new infections and AIDS-related deaths and the UNAIDS goal of ending the AIDS epidemic by 2030.

Information documented to date highlights many failures along the so-called cascade of HIV care, with suboptimal efficiency of HIV testing, linkage to HIV care, ART initiation and viral suppression [10–12]. Estimating the overall proportion of viral suppression and identifying failures along the cascade of care in specific settings is a starting point for strategically planning the way forward towards reaching the UNAIDS 2020 targets and for identifying ways to improve ART program efficiency. Moreover, the majority of the studies published to date are clinic based and thus did not provide insight into those not linked or retained in care [13].

Relying on a representative sample of the adult population from a South-African hyper-endemic peri-urban setting where an intensified HIV prevention program has been conducted since 2008, our main objective was to estimate the proportion of HIV-infected adults with viral suppression, especially among the highly-exposed age groups. The secondary objectives were a) to document completion of each step of HIV cascade and to identify factors associated with their successful completion, and b) to assess the effectiveness of the ART program in preventing AIDS-related deaths between 2005 and 2012.

Methods

Study community

This study was conducted in the township of Orange Farm, located approximately 40km from Johannesburg, South Africa. The adult population is estimated at around 110,000. The township is located in a district with one of the most severe HIV epidemics in the world, with HIV prevalence estimated at 30% among women attending antenatal clinics in 2011 [14]. ART became available in 2004 in the community, but was only available throughout all Orange Farm's clinics in 2005. This later date was retained as the starting date of the ART program for the purpose of our study. Orange Farm was the setting of the first randomized controlled trial on voluntary male medical circumcision (VMMC), conducted between 2002 and 2004 [15], and of an intensified VMMC scale-up program conducted since 2008 [16]. This program includes community mobilization and free VMMC. In the clinics offering VMMC, free HIV counseling and testing (HCT) is also offered.

Survey

We used a one-stage self-weighting sampling design to select a representative random sample of households in the community. Between January and December 2012, every adult aged 18

years or older and having slept at least two nights in the selected households during the previous seven nights were invited to participate in the study. Informed consent was obtained from all participants, interviews were conducted using standardized questionnaires, a genital examination was performed and bloods were collected at the study site. The following information was collected through standardized questionnaires: age, ethnic group, marriage history, occupation, education level, alcohol consumption, age at sexual debut, lifetime number of sexual partners, condom use at last sexual intercourse, HIV testing history (ever/never tested and date of the first HIV test) and, among women, pregnancy history. Among men, a genital examination was performed to determine male circumcision (MC) status. The date of circumcision was also collected.

Laboratory procedure

Each participant was invited to supply a venous blood sample. Samples were collected in plasma preparation tubes and centrifuged. A screening test for HIV (GenscreenTM HIV1/2 version 2, Bio-Rad, Marnes-la-Coquette, France) was performed on all plasma samples. For reactive samples, a confirmatory test was run (VironostikaTM, HIV Uni-Form II plus O, bioMérieux, Boxtel, Netherlands). If the sample reacted positively for both assays, a second confirmatory test was conducted (Murex HIV-1.2.O, Murex Biotech Ltd., Dartford, UK). Plasma samples testing positive for HIV were also tested for the presence of the most common antiretroviral drugs (ARV) currently in use in South Africa (Lamivudine, Stavudine, Zidovudine, Nevirapine, Efavirenz, Ritonavir, Lopinavir, Emtricitabine, Tenofovir, Abacavir, Atazanavir) using ultra performance liquid chromatography coupled with tandem mass spectrometry according to a slightly modified previously published method [17]. Plasma HIV-1 RNA load was determined by reverse-transcription PCR using an assay designed to detect

all M-group subtypes (Amplicor HIV-1 Monitor Test V1.5, Roche Diagnostic System Ins., Branchburg, New Jersey, USA) [18].

Ethics

Ethical clearance for the surveys was granted by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand on May 8, 2007 (M070367).

Outcomes

Additionally to the HIV status of participants, our outcomes included the successive steps of the cascade of HIV care, defined as: i) having been ever tested for HIV; ii) testing positive for the use of any ARV; and iii) having viral suppression, defined as $VL < 400$ copies/mL (alternative thresholds were also used: < 50 or < 1000 copies/mL). We also calculated the ratio of ARV-positive people over those HIV-negative. At the community-level, we calculated the detectable viral load proportion, defined as the proportion of untreated or treated but not virally suppressed HIV-infected people, and as such representing the fraction of the population potentially exposing their sexual partners to HIV [13,19]).

For participants testing positive for the use of ARVs, the ART profile was categorized as definite/probable/possible 1st-line regime, definite/probable/possible 2nd-line regime, or undetermined (see Table S1, Supplemental Digital Content 1, <http://links.lww.com/QAD/A932>, which describes the ART profiles).

Statistical analysis

For each outcome, we calculate the percentage and 95% Confidence Interval. For HIV-positivity and the different steps of the treatment cascade, we identified associated factors through univariate and multivariate Poisson regression, which allowed the calculation of

unadjusted and adjusted Prevalence Rate Ratio (respectively, PRR and aPRR) [20]. Variables considered in the multivariate models included all covariates associated with the studied outcome with a p-value <0.2 in univariate analysis.

We conducted additional analyses restricted to the highly exposed age groups, defined as those age groups with a particularly high HIV incidence rate, including 18-29 year old women and 25-34 year old men [21]. The outcomes were also studied in the sub-population of women reporting having been pregnant during the past 12 months.

The number of participants testing positive for ARVs was expressed as a ratio relative to the number of HIV-negative participants in the sample (number non-directly dependent on ART programs). Using a basic model, (see Text, Supplemental Digital Content 2, <http://links.lww.com/QAD/A932>, which describes the model), we estimated what this ratio would have been if every HIV-infected person in the community had received ART using the treatment threshold of CD4<200cells/ μ L (which since 2005, has corresponded to the 2006 WHO guidelines [2]). This model assumed a stable population and a stable HIV epidemic (*i.e.* HIV incidence roughly equals AIDS-related mortality).

Analyses were performed using the statistical software R [23].

Results

Sample characteristics

A total of 3293 men and 3473 women participated in the study. The overall participation rate was 60%. The mean age (median[Inter-Quartile Range]) was 31.8 years (27.0[22.0-38.6]) among men and 36.0 years (32.6[23.7-46.2]) among women. Background, behavioral and

HIV testing characteristics of the population are presented in Table 1. Among 18-49 year old men (age group targeted for VMMC), the prevalence of MC was 46.2% [95% Confidence Interval: 44.3-48.0%]. Among women, 12.9% [11.8-14.0%] reported having been pregnant during the past 12 months, among whom 93.8% [91.1-96.0%] reported having seen a health provider in relation to the pregnancy.

HIV prevalence and factors associated with HIV-positivity

HIV prevalence was 17.0% [15.7-18.3%] among men and 30.1% [28.5-31.6%] among women (overall: 23.7% [22.7-24.7%]). Age-specific HIV prevalence is presented in Figure 1. Results of the risk factor analysis of HIV-positivity are presented in a table (see Table S2, Supplemental Digital Content 3, <http://links.lww.com/QAD/A932>, which describes the data).

Uptake of HIV testing

Overall, 59.1% [57.4-60.8%] of men and 79.5% [78.2-80.9%] of women reported having been previously tested for HIV. These proportions were 65.7% [62.5-68.7%] and 84.2% [82.3-86.0%], respectively, among the highly-exposed age groups.

Among men, independent predictors of lifetime uptake of HIV testing were having ever been married, being at school, being HIV-positive and being circumcised (Table 2). This latter factor was the strongest predictor of having ever been tested. Among circumcised men, 23.7% [215/694, 20.9-26.6%] of those having ever been tested reported the date of the first HIV test as being within a month of the date of the VMMC.

Among women, independent predictors of lifetime uptake of HIV testing were employment and having been pregnant during the past 12 months. Among women reporting having received prenatal care, 96.2% [93.4-97.9%] reported having been tested for HIV (it is not

known whether they were tested as part of prenatal care), and 33.8% [29.3-38.6%] of those reported that they underwent their first HIV test within the past 12 months.

Among participants testing positive for HIV in this study, 33.9% [29.9-38.0%] of men and 13.2% [11.2-15.4%] of women reported having never been tested for HIV.

ART coverage

Among 558 men and 1041 women testing positive for HIV, 21.0% [17.7-24.6%] and 30.5% [27.7-33.3%], respectively, tested positive for one or more ARV (overall: 27.1% [25.0-29.4%]). Among untreated HIV-positive participants, 39.0% [34.4-43.7%] of men and 16.5% [13.8-19.4%] of women reported having never been tested for HIV.

Factors associated with the use of ARVs among both genders were age and condom use during their last sexual encounter (Table 3). Additionally, being unemployed (vs. employed) among men, and having a low alcohol consumption among women, were independently associated with ARVs-positivity. MC status was not associated with ARVs-positivity, while among women from highly-exposed age groups, recent pregnancy was associated with ARVs-positivity (aPRR=2.08 [1.22-3.57]).

Among the 119 women testing positive for HIV and reporting having been pregnant during the past 12 months, 31.1% [22.9-40.2%] were using ARVs.

Among men testing positive for ARVs, 14.5% [8.7-22.2%] reported having never been tested for HIV. Among women, this figure was 5.7% [3.4-8.8%].

Among the 434 participants testing positive for any ARV, the majority were definitely (303; 69.8%), probably (87; 20.0%) or possibly (11; 2.5%) using first-line regimen ARVs; 16 (3.7%), 8 (1.8%) and 1 (0.2%), respectively, were definitely, probably or possibly using second-line regimen ARVs, while the remaining 8 (1.8%) presented an undetermined profile.

Viral Load distribution among people receiving ART

Among the 432 participants testing positive for ARVs, 405 had an available VL measure.

Among these, the proportion with viral load under the thresholds of 1000copies/mL, 400copies/mL and 50copies/mL were respectively 94.1% [91.3-96.2%]; 91.9% [88.7-94.3%] and 78.3% [73.9-82.2%]. In univariate analysis, none of the studied risk factors were found to be significantly associated with VL suppression (see Table S3, Supplemental Digital Content 4, <http://links.lww.com/QAD/A932>, which describes the results of the analysis). None of the participants with a count of VL>1000copies/mL was under a definite, probable or possible 2nd-line ART regime, and thus potentially in need of a 3rd-line regime.

Overall cascade of HIV care and viral suppression

Figure 2 summarizes the cascade of HIV care in Orange Farm. Overall, 23.7% [21.6-25.9%] of all HIV-infected people had a VL<400copies/mL. This proportion was significantly higher among women (27.0% [24.3-29.9%]) than among men (17.5% [14.4-20.9%], $p<0.001$); and was lower among the highly-exposed age groups: 15.6% [12.1-19.7%] among women and 8.4% [5.0-13.1%] among men (overall: 13.0% [10.4-16.1%]). At the population level, the detectable viral load proportion was 17.8% [16.9-18.7%] (21.6% [20.3-23.0%] among women and 13.8% [12.6-15.0%] among men).

Assessing the effectiveness of ART programs

We calculated the ratio of people using ARVs to those HIV-negative to be 0.084. Using the model described in Annex 1, we estimate that, if ART programs implemented in Orange Farm since 2005 were successful in averting every AIDS-related death, this ratio would be 0.184.

By comparing the observed ratio to that calculated under the hypothesis of maximum

effectiveness, we estimate the effectiveness of the ART program in preventing AIDS-related deaths to be 46%.

Discussion

Main results

In 2012, in a peri-urban South-African community hyper-endemic for HIV, 23.7% of all HIV-infected people were virally suppressed. Furthermore, this proportion was significantly lower among age groups most exposed to HIV infection. These levels can be considered as a starting point for developing strategic plans for reaching the proposed UNAIDS target for 2020, namely to achieve viral suppression among 73% of all people living with HIV. A large majority of the population reported having ever been tested for HIV, whereas just over one in four people living with HIV were receiving ART. When correctly taken, ART was highly effective in achieving viral suppression. Using a basic model, we also demonstrate that ART programs conducted until 2012 have had an effectiveness of 47 to 67% in preventing AIDS-related deaths in this community.

Limitations

This study has several limitations. We defined steps along the cascade of HIV care that differ from those suggested in relation to the proposed UNAIDS target [9], with specific reference to the first two steps (percentage of lifetime HIV testing and proportion of those testing positive for the use of ARVs). We cannot infer the percentage of diagnosed HIV infections from information on lifetime uptake of HIV testing. However, the percentage of HIV-infected participants reported having never been tested for HIV may be interpreted as a lower boundry of the proportion of undiagnosed HIV infections. Furthermore, the proportion of HIV-infected participants testing positive for ARVs may underestimate the true proportion of participants

having initiated ART, because participants receiving ART but not taking treatment at the time of the survey would test negative for ART. However, our third cascade indicator, the percentage of HIV-infected participants with suppressed VL, integrates information from previous steps and is comparable with that proposed by UNAIDS. Moreover, the results of this study do not rely on longitudinal data, and thus do not allow for a comprehensive understanding of the dynamics that may affect the different steps along the HIV cascade [24]. However, the cross-sectional nature of our data presents a snapshot of the cascade of care in Orange Farm that may be representative at the community level. Moreover, as we rely on data collected from a representative sample of the population, our indicator has the advantage of being less affected by reporting or participation bias than results obtained in clinical settings [13]. Other limitations were that a) we have used high incidence groups as a proxy for high transmitters and b) the questionnaire should have included questions about date of most recent HIV test, as well as date of the first test, and some indication of how many tests there were in between.

HIV testing

The proportions of the population having previously been tested for HIV in our study are very similar to those documented at the national level in South African [21]. In particular, almost all women having recently been pregnant reported having ever been tested for HIV, which may reflect the impact of prevention of mother-to-child transmission programs [25,26]. The level of lifetime HIV testing documented in South Africa is among the highest in sub-Saharan Africa [27]. However, in this study, at least 17% and 39% of HIV-infected women and men did not know their HIV status, which highlights the need to strengthen HIV testing programs. More specifically, repeat HIV testing should be promoted to allow earlier linkage to care and ART initiation [28]. Our data did not provide direct information on this issue, but results on

lifetime testing suggest that the proportion of people who have been repeatedly tested is low, especially among men. Previous studies conducted in South Africa suggest that the proportion of repeat testers among HIV test users ranges from 26% to 71%, depending on the local and testing context [29–31].

ART coverage

The proportion of HIV-infected people testing positive for the use of ARVs in our study was slightly lower than that estimated in a 2012 national population-based survey in South Africa (31.2%), with the proportion being consistently higher among women than men [21]. In 2013, in a township in the Cape Town area, Kranzer et al reported that 33.5% of all HIV-infected individuals were receiving ART [32]. This slightly higher estimate may be explained by over-estimation due to self-reporting. The proportion of people on second-line treatment regimes in our study was close to the WHO projections for low- and middle- income countries [33].

Effect of VMMC campaigns

The study was conducted in a community where VMMC has been intensively promoted as part of a combined HIV prevention package, including HIV counseling and testing (HCT), since 2008 [16]. We therefore observed a probable secondary benefit of VMMC programs: circumcised men were more likely to have ever been tested for HIV than uncircumcised men. Moreover, among circumcised men, nearly one in four reported having undergone a first HIV test as part of the VMMC procedure.

Estimation of ART program effectiveness

While significant progress has been made in scaling up the provision of ART to eligible people living with HIV in sub-Saharan Africa, coverage remains sub-optimal. For example, in 2009, ART coverage in South Africa, using the 2006 WHO guidelines ($CD4 < 200 \text{ cells}/\mu\text{L}$) was estimated at around 56% [34]. National-level coverage was estimated by UNAIDS using

a model which is based on national epidemiological data and assumptions on average survival rates with and without ART, and average time between sero-conversion and eligibility for treatment [35]. Using a basic model and relying on the same kind of data and assumptions, we estimated that the effectiveness of ART programs was less than 50% in preventing AIDS-related deaths in the Orange Farm community between 2005 and 2012. These results highlight the need for better efficiency in every step of the cascade of HIV care, from HIV testing and diagnosis, to ART initiation, retention in care and adherence to treatment [11,36].

Level of viral suppression and impact on HIV incidence

The level of viral suppression among the adult population infected with HIV in the Orange Farm community was found to be very similar to the 2013 UNAIDS estimate for Sub-Saharan Africa of 24% [12]. A rough estimate of the impact of such a level of viral suppression might be obtained by comparing the detectable viral load proportion, *i.e.* the fraction of the population potentially exposing partners to HIV [13,19] to the crude HIV prevalence in the community. This basic calculation suggests a decrease in HIV incidence of 25% due to the preventive effect of ART. However, the true preventive effect of ART may have been lower, as lower levels of viral suppression were observed in the younger age groups among whom HIV incidence is at its highest levels. At the 2012 coverage level, we therefore cannot expect ART to have had a large impact on HIV incidence in this community.

Optimistic results

Our study shows that people receiving ART were more likely to report condom use at the last sexual encounter compared to untreated HIV-infected participants. This association may reflect the behavioral preventive effect of ART that has previously been described [37–40].

Another encouraging result from our study is that, when ARVs are correctly taken, and thus detectable in blood, their effectiveness in suppressing HIV viral load is high. Close to all treated participants presented a VL<1000copies/mL, which is the usual threshold of effective treatment. However, our results do not provide evidence to help understand why some patients interrupt or are insufficiently adherent to their treatment.

Conclusions

This study allowed the assessment of the gap between the 2012 level of viral suppression among the HIV-infected population of a hyper-endemic community in South Africa and the proposed UNAIDS treatment targets for 2020. The Orange Farm township is fairly representative of other semi-urban areas and our results may therefore be generalizable to those obtained in other sub-Saharan hyper-endemic semi-urban settings. While good progress has been made in the last decade in providing treatment to people living with HIV, the study shows that ART programs in 2012 were still suboptimal in delivering treatment to every person eligible for treatment according to the 2006 WHO treatment guidelines. Changing the HIV treatment eligibility criteria in itself will not be sufficient to reach the 2020 targets; there is an urgent need to improve the effectiveness of ART programs. Our results suggest that HIV testing and ART initiation, rather than ART effectiveness if actually taken, are crucial steps in need of improvement in order to achieve effective ART programs.

Acknowledgements

We would like to thank the entire research team of Progressus Research and Development and specifically Agenda Gumbo for organizing the data entry of this study. We would like to thank Gaph Phatedi and Audrey Mkwanazi for support. We would like to thank the community of Orange Farm and specifically the Community Advisory Board of Orange Farm chaired by Portia Ntshangase.

Source of funding

We acknowledge support from the French Research Agency ANRS (Grant 12285).

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

All authors have read and approved the manuscript. Substantial contributions to conception and design: BA, JB, RRT, DT and PL. Performed the acquisition of data: RRT, DT, JB and PL. Conducted the biological analysis of samples: EC, BS, AP, DAL and AP. Performed the statistical analysis: KJ, BA. Interpretation of data: KJ, BA, GP, AP, PL, JB and EG. Wrote the first draft: KJ and BA. Contributed to writing the paper: AP, JB, EG, DAL and GP.

Previous presentation

Preliminary and partial results were presented at the 8th IAS Conference on HIV Pathogenesis, Treatment & Prevention 19–22 July 2015, Vancouver, Canada (Abstract MOAC0102) and published as abstract in J Int AIDS Soc. 2015; 18(5Suppl 4): 20479.

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Table 1. Background, behavioral and HIV testing characteristics of the study population in Orange Farm, 2012.

	Men (N=3293)	Women (N=3473)
	%*	%*
Age		
18-24	41.5% (1367/3293)	30.3% (1053/3473)
25-29	18.4% (606/3293)	13.8% (481/3473)
30-34	9.9% (326/3293)	10.7% (373/3473)
35-39	7.3% (239/3293)	10.0% (348/3473)
>=40	22.9% (755/3293)	35.1% (1218/3473)
Ethnic group		
Sotho	34.0% (1120/3292)	37.3% (1295/3472)
Zulu	41.0% (1349/3292)	37.6% (1306/3472)
Other	25.0% (823/3292)	25.1% (871/3472)
Occupation		
Employed	44.7% (1471/3291)	26.7% (926/3473)
Unemployed	34.9% (1149/3291)	55.5% (1926/3473)
Other	20.4% (671/3291)	17.9% (621/3473)
Marriage history		
Never married	55.6% (1831/3293)	40.4% (1404/3473)
Ever married	44.4% (1462/3293)	59.6% (2069/3473)
Education level		
<Level 12 and not at school	56.1% (1847/3293)	64.0% (2221/3469)
Level 12 completed	11.8% (387/3293)	7.6% (263/3469)
At school (<level 2)	32.2% (1059/3293)	28.4% (985/3469)
Alcohol consumption		
<1 per week	67.5% (2224/3293)	90.8% (3150/3471)
>=1 per week	32.5% (1069/3293)	9.2% (321/3471)

Age at sexual debut		
≥18	33.6% (1074/3198)	53.1% (1797/3382)
<18	66.4% (2124/3198)	46.9% (1585/3382)
Lifetime number of sexual partners		
<5 partners	32.6% (1073/3293)	68.8% (2388/3472)
≥5 partners	67.4% (2220/3293)	31.2% (1084/3472)
Condom use at last sex		
Yes	53.0% (1693/3193)	33.9% (1145/3377)
No	47.0% (1500/3193)	66.1% (2232/3377)
Male circumcision status		
Uncircumcised	56.3% (1849/3287)	Not applicable
Circumcised	43.7% (1438/3287)	
Pregnancy in the last 12 months		
No	Not applicable	87.1% (3023/3469)
Yes		12.9% (446/3469)
Lifetime uptake of HIV test		
Never tested	40.9% (1346/3291)	20.5% (710/3471)
Ever tested	59.1% (1945/3291)	79.5% (2761/3471)
HIV status		
Negative	83.0% (2733/3291)	69.9% (2423/3464)
Positive	17.0% (558/3291)	30.1% (1041/3464)

*Percentage are expressed as proportion of non-missing values.

Table 2. Factor associated with lifetime uptake of HIV testing among men and women in Orange Farm, 2012.

		Men (N=3291)			Women (N=3471)		
		% ever tested (n)	PRR[95%IC]	aPRR[95%IC]	% ever tested (n)	PRR[95%IC]	aPRR[95%IC]
Age	18-24	52.6% (1366)	1	1	81.2% (1052)	1	1
	25-29	64.2% (606)	1.22[1.08-1.38]	1.13[0.99-1.30]	95.6% (481)	1.18[1.05-1.32]	1.09[0.97-1.23]
	30-34	68.4% (326)	1.30[1.12-1.51]	1.21[1.02-1.43]	92.8% (373)	1.14[1.01-1.29]	1.06[0.92-1.21]
	35-39	61.5% (239)	1.17[0.98-1.39]	1.06[0.86-1.30]	90.8% (347)	1.12[0.98-1.27]	1.04[0.90-1.20]
	≥40	61.9% (754)	1.18[1.05-1.32]	1.13[0.96-1.32]	64.5% (1218)	0.79[0.72-0.88]	0.79[0.70-0.89]
Ethnic group	Sotho	57.0% (1119)	1	Not entered	78.3% (1295)	1	Not entered
	Zulu	60.0% (1349)	1.05[0.95-1.17]		82.8% (1305)	1.06[0.97-1.15]	
	Other	60.5% (822)	1.06[0.94-1.19]		76.6% (870)	0.98[0.89-1.08]	
Occupation	Employed	61.5% (1470)	1	1	83.5% (926)	1	1
	Unemployed	59.7% (1148)	0.97[0.88-1.07]	1.02[0.92-1.12]	82.5% (1924)	0.99[0.91-1.08]	0.94[0.86-1.03]
	Other	52.8% (671)	0.86[0.76-0.97]	0.98[0.83-1.14]	64.6% (621)	0.77[0.69-0.87]	0.76[0.66-0.88]

Marriage history						
Never married	54.3% (1830)	1	1	81.3% (1403)	1	Not entered
Ever married	65.1% (1461)	1.20[1.10-1.31]	1.18[1.05-1.32]	78.4% (2068)	0.96[0.89-1.04]	
Education level						
<Level 12 and not at school	56.9% (1845)	1	1	76.3% (2219)	1	1
Level 12 completed	47.3% (387)	0.83[0.71-0.97]	0.99[0.80-1.23]	74.1% (263)	0.97[0.84-1.12]	1.18[0.98-1.42]
At school (<level 2)	67.3% (1059)	1.18[1.08-1.30]	1.21[1.09-1.34]	88.2% (985)	1.16[1.07-1.25]	1.09[0.99-1.19]
Alcohol consumption						
<1 per week	59.8% (2223)	1	Not entered	79.4% (3149)	1	Not entered
≥1 per week	57.7% (1068)	0.96[0.88-1.06]		80.6% (320)	1.02[0.89-1.15]	
Age at sexual debut						
≥18	60.8% (1073)	1	Not entered	78.1% (1797)	1	1
<18	59.0% (2123)	0.97[0.88-1.07]		83.4% (1583)	1.07[0.99-1.15]	1.05[0.97-1.13]
Lifetime number of sexual partners						
<5 partners	54.5% (1072)	1	1	77.4% (2386)	1	1
≥5 partners	61.3% (2219)	1.13[1.02-1.24]	1.05[0.95-1.16]	84.3% (1084)	1.09[1.01-1.18]	1.05[0.97-1.14]
Condom use at last sex						
Yes	59.3% (1693)	1	Not entered	84.8% (1145)	1	1
No	60.1% (1498)	1.01[0.93-1.11]		78.4% (2230)	0.92[0.85-1.00]	0.99[0.91-1.07]

Male circumcision status						
Uncircumcised	53.6% (1849)	1	1	Not applicable	Not applicable	Not applicable
Circumcised	66.2% (1437)	1.23[1.13-1.35]	1.29[1.18-1.42]			
Pregnancy in the last 12 months						
No	Not applicable	Not applicable	Not applicable	77.2% (3021)	1	1
Yes				95.7% (446)	1.23[1.12-1.37]	1.11[1.00-1.23]
HIV status						
Negative	57.6% (2731)	1	1	76.4% (2422)	1	1
Positive	66.1% (558)	1.15[1.02-1.28]	1.14[1.01-1.29]	86.8% (1040)	1.14[1.05-1.23]	1.06[0.97-1.15]

PRR: unadjusted Prevalence Rate Ratio. 95%CI: 95% Confidence Interval. aPRR: adjusted Prevalence Rate Ratio.

PRR and aPRR were computed from univariate and multivariate Poisson regression. The multivariate models included all covariate associated with the outcome with a p-value <0.2 in univariate analysis.

Table 3. Factor associated with positivity to ARV among HIV-infected men and women in Orange Farm, 2012.

		Men (N=558)			Women (N=1041)		
		% positive to ART (n)	PRR[95%IC]	aPRR[95%IC]	% positive to ART (n)	PRR[95%IC]	aPRR[95%IC]
Age							
	18-24	7.0% (71)	1	1	13.1% (183)	1	1
	25-29	8.4% (107)	1.19[0.41-3.89]	2.35[0.67-10.94]	22.9% (192)	1.75[1.07-2.92]	1.63[0.99-2.74]
	30-34	11.5% (96)	1.63[0.59-5.16]	3.71[1.09-17.17]	30.9% (188)	2.35[1.48-3.85]	2.07[1.28-3.45]
	35-39	24.0% (104)	3.41[1.42-10.11]	6.87[2.23-30.29]	37.1% (167)	2.83[1.79-4.62]	2.39[1.48-3.99]
	≥40	37.2% (180)	5.29[2.36-15.09]	9.52[3.19-41.32]	41.5% (311)	3.16[2.09-5.01]	2.77[1.77-4.53]
Ethnic group							
	Sotho	24.2% (190)	1	Not entered	31.2% (384)	1	Not entered
	Zulu	17.2% (227)	0.71[0.46-1.09]		28.0% (400)	0.90[0.69-1.16]	
	Other	22.7% (141)	0.94[0.59-1.47]		33.2% (256)	1.06[0.80-1.40]	
Occupation							
	Employed	17.3% (318)	1	1	33.4% (296)	1	Not entered
	Unemployed	26.4% (193)	1.53[1.04-2.24]	1.54[1.04-2.27]	30.0% (641)	0.90[0.70-1.15]	
	Other	23.4% (47)	1.35[0.67-2.48]	1.23[0.55-2.44]	25.0% (104)	0.75[0.48-1.13]	

Marriage history						
Never married	16.6% (181)	1	1	22.7% (388)	1	1
Ever married	23.1% (377)	1.39[0.93-2.14]	0.82[0.52-1.34]	35.1% (653)	1.55[1.21-1.99]	1.19[0.91-1.56]
Education level						
<Level 12 and not at school	25.0% (400)	1	1	32.9% (765)	1	1
Level 12 completed	25.0% (20)	1.00[0.35-2.21]	0.99[0.23-2.81]	17.0% (53)	0.52[0.25-0.94]	0.64[0.30-1.18]
At school (<level 2)	8.7% (138)	0.35[0.18-0.61]	0.44[0.22-0.78]	24.9% (221)	0.76[0.56-1.00]	0.94[0.68-1.26]
Alcohol consumption						
<1 per week	23.3% (344)	1	1	31.6% (919)	1	1
≥1 per week	17.3% (214)	0.74[0.50-1.09]	0.74[0.49-1.08]	21.5% (121)	0.68[0.44-1.00]	0.68[0.44-0.99]
Age at sexual debut						
≥18	20.4% (230)	1	Not entered	31.2% (500)	1	Not entered
<18	20.9% (326)	1.02[0.71-1.49]		29.8% (541)	0.95[0.77-1.19]	
Lifetime number of sexual partners						
<5 partners	15.5% (129)	1	1	28.4% (589)	1	1
≥5 partners	22.6% (429)	1.46[0.92-2.43]	1.36[0.84-2.34]	33.2% (452)	1.17[0.94-1.46]	1.07[0.86-1.34]
Condom use at last sex						
Yes	27.2% (276)	1	1	36.7% (447)	1	1
No	14.3% (280)	0.53[0.36-0.77]	0.50[0.33-0.73]	25.8% (593)	0.70[0.56-0.88]	0.67[0.54-0.84]

Male circumcision status						
Uncircumcised	20.7% (435)	1	Not entered	Not applicable	Not applicable	Not applicable
Circumcised	22.1% (122)	1.07[0.68-1.62]				
Pregnancy in the last 12 months						
Yes	Not applicable	Not applicable	Not applicable	30.0% (902)	1	
No				32.8% (137)	1.10[0.79-1.49]	

ARV: Antiretroviral drugs. PRR: unadjusted Prevalence Rate Ratio. 95%CI: 95% Confidence Interval. aPRR: adjusted Prevalence Rate Ratio.

PRR and aPRR were computed from univariate and multivariate Poisson regression. The multivariate models included all covariate associated with the outcome with a p-value <0.2 in univariate analysis.

Figure legend

Fig. 1: HIV prevalence across age groups among men and women in Orange Farm, 2012.

Fig. 2. Percentage of ART-positivity and suppressed VL in Orange Farm, 2012.

The dotted bold line indicates the UNAIDS 2020 targets[9].

ART: Antiretroviral treatment; VL: Viral Load. Suppression threshold: VL<400 copies/mL.

Highly exposed age group: 25-34y among men; 18-29y among women.