

HIV incidence and prevalence among cohorts of women with higher risk behaviour in Bloemfontein and Rustenburg, South Africa: a prospective study

Paul J Feldblum,¹ Mary H Latka,² Johann Lombaard,³ Candice Chetty,² Pai-Lien Chen,¹ Connie Sexton,^{1,*} Shelly Fischer¹

To cite: Feldblum P, Latka M, Lombaard J, *et al.* HIV incidence and prevalence among cohorts of women with higher risk behaviour in Bloemfontein and Rustenburg, South Africa: a prospective study. *BMJ Open* 2012;**2**:e000626. doi:10.1136/bmjopen-2011-000626

► Prepublication history for this paper is available online. To view these files please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2011-000626>).

Received 1 December 2011
Accepted 16 January 2012

*Now at the US Centers for Disease Control and Prevention.

This final article is available for use under the terms of the Creative Commons Attribution Non-Commercial 2.0 Licence; see <http://bmjopen.bmj.com>

¹FHI 360, Research Triangle Park, USA

²The Aurum Institute, Johannesburg, South Africa

³JOSHA Research, Bloemfontein, Free State, South Africa

Correspondence to

Dr Paul Feldblum;
pfeldblum@fhi360.org

ABSTRACT

Objectives: The primary objective was to measure HIV incidence in two prospective cohorts of HIV-negative women. Secondary objectives included measuring pregnancy rates and participant retention rates.

Design: Cross-sectional HIV screening of women selected for higher risk behaviours, with a subsequent prospective study of uninfected women, followed monthly for up to 6 months.

Setting: Clinics established for research purposes in Bloemfontein and Rustenburg, South Africa.

Participants: The authors enrolled women 18–35 years old and presumed at higher risk of sexual acquisition of HIV as indicated by self-reported sexual behaviour or recent sexually transmitted infection symptoms. In Bloemfontein, 1364 women were screened, 1154 were eligible for HIV testing and 1145 agreed to be tested. The prospective study enrolled 401 HIV-negative women. In Rustenburg, 946 women were screened, 540 were eligible and underwent HIV testing and 223 HIV-negative women entered the prospective study.

Primary and secondary outcomes: Baseline prevalences of HIV infection and HIV incidence rates in the prospective cohorts, according to a double rapid test algorithm with a third rapid test for discrepant or indeterminate results. Pregnancy prevalences and pregnancy incidence rate in Bloemfontein. Participant retention rates in the prospective cohort until the study end.

Results: In Bloemfontein, 1145 women were tested, 391 entered follow-up and 92.3% of participants completed six study visits. In Rustenburg, 540 women were tested, 194 entered follow-up and retention up to the point of early study termination was 88.6%. Overall HIV prevalence was 21.2% (95% CI 18.9% to 23.6%) in Bloemfontein and 23.5% (95% CI 19.9% to 27.1%) in Rustenburg. Overall HIV incidence was 5.5/100 person-years (95% CI 2.5 to 10.4) in Bloemfontein and 3.0/100 person-years (95% CI 0.4 to 10.8) in Rustenburg. Cross-sectional pregnancy prevalences were 6.5% in Bloemfontein and 8.6% in Rustenburg.

ARTICLE SUMMARY

Article focus

- Primary objective: measure HIV incidence and prevalence among women in two prospective cohorts selected for higher risk behaviours.
- Secondary objective 1: measure pregnancy rates.
- Secondary objective 2: measure retention rates.

Key messages

- We measured the HIV burden among women selected to be at higher risk in two smaller South African cities, while training new clinical research groups there.
- HIV seroprevalence was 21.2% in Bloemfontein and 23.5% in Rustenburg.
- HIV incidence rates were 5.5/100 person-years in Bloemfontein and 3.0/100 person-years in Rustenburg.

Study strengths

- Longitudinal design with high retention rates.
- Highly accurate classification of the HIV outcome, using multiple rapid tests monthly, confirmed by later PCR testing.
- Testing of stored baseline specimens to pinpoint seroconversion and rule out acute prestudy infections.
- Direct prospective measurement of HIV infection circumvented the lingering issues with the accuracy of cross-sectional incidence estimation.

Study limitations

- Unknown validity of self-reported sexual behaviours.
- Relatively small study size precluded multivariable Cox regression analysis.
- Selective recruitment means that the prevalence and incidence figures are not representative of women in these two cities.
- The lack of sexually transmitted infection diagnostic testing precluded evaluating associations between HIV and other infections.

Conclusions: The authors observed substantial HIV incidence rates in both cohorts. Vigorous prevention efforts are needed in these smaller cities.

INTRODUCTION

HIV/AIDS continues to exact a massive toll on the health, economics and political infrastructure of communities around the world. In sub-Saharan Africa, the most heavily affected region, an estimated 22.4 million people were reported to be living with HIV in 2008.¹ While recent prevention trials assessing male circumcision, antiretroviral gel use and pre-exposure prophylaxis have shown significant promise,^{2–5} studies to corroborate these results and to evaluate new prevention methods will be required. To meet the ongoing need for research sites in countries with substantial HIV burden, FHI 360's Site Identification and Development Initiative (SIDI) undertook the development of previous research naïve sites in six countries to conduct future HIV prevention research.

The SIDI team partnered with groups in two South African cities for clinical research development: Bloemfontein in the Motheo District of Free State Province and Rustenburg in the Bojanala District of Northwest Province. District-level HIV prevalence rates among antenatal women aged 15–49 years were 27.8% and 34.9%, respectively, in 2009; provincial HIV prevalence rates were 30.1% (Free State) and 30% (Northwest).⁶ HIV incidence rates for both sites had not been measured.

The goal of the SIDI project was to develop HIV prevention research capacity and to determine the suitability of each site to implement future HIV prevention clinical trials. Each site conducted its own prevalence and incidence study using a similar protocol. The primary objective of each study was to measure HIV incidence in a prospective cohort of HIV-negative women at each study site. Secondary objectives included measuring pregnancy rates and participant accrual and retention rates in the cohort.

METHODS

Study design and recruitment

The study comprised cross-sectional screening with HIV testing, followed by a prospective cohort study with up to six monthly follow-up visits. In Bloemfontein, the study was conducted at the JOSHA Research Centre. Bloemfontein and the surrounding Mangaung municipality comprise a population of approximately 600 000 people. JOSHA is an independent clinical research facility that can draw participants from affiliated general practices as well as from cooperating government clinics. Participants for the cross-sectional screening were recruited using methods developed based on the feedback from community engagement activities led by the Mangaung-University Community Partnership Program (MUCPP) and input from key stakeholders in the community.

Recruitment methods included (1) recruitment from HIV counselling and testing, sexually transmitted disease and family planning clinics; (2) targeted outreach activities in the community and (3) referrals from other clinics. Participants for the prospective study were recruited from among the HIV-negative participants in cross-sectional screening.

In Rustenburg, with a population estimated at 350 000 in the 2001 census but which has grown considerably since then, the study was conducted at The Aurum Institute's Rustenburg Research Centre located downtown. The Rustenburg economy is largely driven by the platinum mining industry and is home to a large, diverse and growing influx of residents attracted to the area for work in the mining industry. The Aurum Institute (formerly the Aurum Institute for Health Research) is a non-profit research organisation that began activities in March 2007 to prepare the Rustenburg Municipality to engage in epidemiologic studies and future clinical research trials. Participants for the cross-sectional screening were recruited from a variety of clinic-based and community settings, which included an emphasis on local colleges. To facilitate recruitment and enrolment for cross-sectional screening, the protocol was amended twice late in the study to add respondent-driven sampling for recruitment (not inference) purposes⁷ and to liberalise the sexual behaviour eligibility criterion. Both men and women were recruited for cross-sectional screening in Rustenburg, but only HIV-negative women were invited to participate in the prospective study as there was a separate male cohort study there.

Study procedures

Following the informed consent process and assignment of a participant number, volunteers were considered enrolled. Enrolled participants were screened for eligibility for cross-sectional testing using a demographic and HIV risk factor questionnaire. Recruitment and screening staff at both sites were blind to the specific behavioural eligibility criteria to avoid the spread of information through the community and to prevent volunteers from altering self-reported behaviours to gain access to the study. All participants were asked the full questionnaire regardless of their initial answers.

Only eligible women were tested. Eligibility for HIV and pregnancy testing was determined by age (18–35 at the time of screening) and presumed higher risk of sexual acquisition of HIV as defined by at least one of the following self-reported criteria in the past 3 months: (1) treatment for, diagnosis of or signs/symptoms of a sexually transmitted infection (STI); (2) vaginal or anal intercourse with more than one partner (unprotected intercourse in Rustenburg only); (3) vaginal or anal intercourse with a new sexual partner (unprotected intercourse in Rustenburg only) or (4) sex with an HIV-infected partner who is not using antiretroviral therapy. Near the end of the Rustenburg study, we revised these criteria to remove the requirements for multiple partners and unprotected sexual acts for women, as we

suspected that we were screening out many higher risk women and that condom use reporting was not accurate. Participants deemed eligible underwent HIV testing within the context of HIV pretest and post-test counselling in accordance with national guidelines. Women also had urine pregnancy tests. Results of both tests were provided to participants during their visits.

Women were eligible to enter the prospective cohort study if they met the cross-sectional age and behavioural criteria, were HIV negative and pregnancy negative and were not planning to relocate from the area in the near future. The target prospective study size was the first 400 eligible women at each site, followed monthly for up to 6 months. At each monthly visit, participants provided updated medical and behavioural information, underwent HIV and pregnancy testing, received syndromic management for STIs (as needed), were counselled on HIV risk reduction practices and received free condoms.

HIV testing was performed on finger prick blood samples using a double rapid test algorithm with the Abbott Determine HIV-1/2 and Trinity Biotech Uni-Gold run in parallel. Two positive results were deemed positive and two negative results were deemed negative, which exceeded national HIV testing guidelines. Discrepant or indeterminate samples were tested with a third rapid test, SD BIOLINE HIV-1/2 3.0, as a tie-breaker. Pregnancy testing was performed on urine samples using the Quidel QuickVue hCG-Combo test. All tests were run according to the manufacturers' specifications.

Participants who tested HIV positive at screening or during the cohort study were referred for care in accordance with local guidelines. In addition, those participants who seroconverted during the prospective phase were intensely counselled about secondary HIV prevention in the acute infection period and in Rustenburg were invited to join a seroconverter cohort with continued close monitoring. Participants who were found to be pregnant were referred for antenatal care. Participants who became pregnant during follow-up continued to make study visits.

Ethical considerations

The protocols, informed consent forms, participant education and recruitment materials, case report forms and compensation amount for visits (50 rand) were reviewed and approved by the FHI 360 ethics committee and the local ethics committees, the University of Free State ethics committee for Bloemfontein and the University of KwaZulu Natal Biomedical Research Ethics Committee for Rustenburg.

We obtained written informed consent from each participant prior to enrolment and data collection. Written consent was also obtained for long-term specimen storage and possible future testing, although consent for specimen storage was not required for study participation. Informed consent forms were available in English and were translated into local languages, Sesotho (Bloemfontein) and Sestwana and IsiXhosa

(Rustenburg), to enhance comprehension. Volunteers had their choice of language for the informed consent process, which was witnessed and verified by a non-study staff person for illiterate or low-literate participants.

Statistical analysis

All eligible participants were included in the data analysis. For each site, we summarised participants' socio-demographic characteristics, self-reported STI symptoms and HIV risk behaviours at baseline for cross-sectional screening participants and those women who entered the prospective study. We calculated baseline prevalences of HIV infection and pregnancy among women, along with 95% CIs. We used univariate and multivariable logistic regression analysis to evaluate the association between risk factors and prevalent HIV infection.

The incidence rate was calculated as the number of post-enrolment HIV seroconversions divided by the person-years (PY) of observation accumulated by the cohort. We calculated 95% CI using exact methods under the assumption that the number of HIV infections follows a Poisson distribution. We used proportional hazards regression to evaluate the associations between incident HIV infection and possible HIV risk factors including time-dependent participant characteristics and time-varying risk behaviours and self-reported STI symptoms. Due to the small number of HIV seroconversions, we did univariate proportional hazards regression only. Data analyses were performed using SAS V.9.2.

RESULTS

Eligible populations

In Bloemfontein, the cross-sectional screening enrolled 1364 women between February and October 2009. Of the 1364 enrolled women, 1154 were determined to be eligible for testing and 1145 (84% of enrollees) chose to be tested in cross-sectional screening. Virtually all of the women who were screened out from cross-sectional testing failed to satisfy the behavioural or STI risk criteria. The prospective study enrolled 401 HIV-negative women volunteers from screening. Of those 401 women, 399 were determined to be eligible and 391 entered follow-up and were tested. 92.3% of participants completed six study visits, for a median 5.6 person-months of observation and a total 164.4 PY.

In Rustenburg, cross-sectional screening enrolled 946 women and 968 men between November 2008 and December 2009. Data on the male participants are not presented here. Of the 946 enrolled women, 540 (57%) were eligible and underwent testing in cross-sectional screening; virtually all of the women who were screened out from cross-sectional testing did not satisfy the behavioural or STI risk criteria. The prospective study enrolled 223 HIV-negative women volunteers, of whom 194 yielded HIV test data. In Rustenburg, many women screened out from the prospective study due to plans to re-locate. Completion of follow-up in the prospective study was hindered when it was ended prematurely due to funding shortfalls, but retention in follow-up up to the

HIV incidence in two South African cohorts

point of study termination was 88.6% with a median 4.1 person-months of observation and a total 67.1 PY.

Participant characteristics

Large percentages of participants in cross-sectional screening at both sites were ≤ 21 years, had a high school-level education, were not employed, were unmarried and

lived with family members (table 1). About one-third of the women were using an effective contraceptive at each site (hormonal method or IUCD: 38.3% in Bloemfontein and 32.9% in Rustenburg; table 1). STI testing was not done; self-reported STI signs/symptoms at baseline ranged from 2% to 15% prevalence in Bloemfontein and from 22% to 37% in Rustenburg.

Table 1 Participant features (N (%)) of eligible women at inception of cross-sectional screening and prospective study in Bloemfontein and Rustenburg sites

	Bloemfontein		Rustenburg	
	Cross-sectional, N=1154	Prospective, N=399	Cross-sectional, N=540	Prospective, N=223
Age				
<21	520 (45.1)	206 (51.6)	239 (44.2)	115 (51.6)
22–24	259 (22.4)	92 (23.1)	130 (24.1)	53 (23.8)
25–31	284 (24.6)	76 (19.1)	138 (25.6)	46 (20.6)
>31	91 (7.9)	25 (6.3)	33 (6.1)	9 (4.0)
Education				
None—grade 5	32 (2.8)	7 (1.8)	4 (0.8)	0 (0.0)
Grades 6–9	181 (15.7)	49 (12.3)	27 (5.0)	10 (4.5)
Grades 10–12	860 (74.5)	333 (83.5)	454 (84.1)	188 (84.3)
University/college/graduate	81 (7.0)	10 (2.5)	55 (10.2)	25 (11.2)
Employment				
No, unemployed	1000 (86.7)	352 (88.2)	463 (85.7)	196 (87.9)
Yes, part time	78 (6.8)	25 (6.3)	31 (5.7)	11 (4.9)
Yes, full time	76 (6.6)	22 (5.5)	46 (8.5)	16 (7.2)
Whom you live with				
Alone	45 (3.9)	12 (3.0)	25 (4.6)	8 (3.6)
Spouse	52 (4.5)	15 (3.8)	15 (2.8)	8 (3.6)
Family/relatives	859 (74.4)	315 (78.9)	375 (69.4)	160 (71.8)
Roommate/friend	103 (8.9)	34 (8.5)	28 (5.2)	12 (5.4)
Partner	95 (8.2)	23 (5.8)	97 (18.0)	35 (15.7)
Married				
No	1056 (91.5)	369 (92.5)	507 (93.9)	211 (94.6)
Yes	98 (8.5)	30 (7.5)	33 (6.1)	12 (5.4)
Contraceptive use				
None	540 (46.9)	182 (45.6)	157 (29.1)	58 (26.0)
Oral	55 (4.8)	20 (5.0)	24 (4.4)	19 (8.5)
Injectable	384 (33.3)	138 (34.6)	132 (24.4)	65 (29.2)
IUCD	2 (0.2)	0 (0.0)	1 (0.2)	1 (0.5)
Condoms	148 (12.9)	52 (13.0)	201 (37.2)	80 (35.9)
Other	23 (2.0)	7 (1.8)	1 (0.2)	0 (0.0)
Missing	2 (0.2)	0 (0.0)	24 (4.4)	0 (0.0)
STI signs/symptoms				
Vaginal discharge	155 (13.4)	52 (13.0)	154 (28.5)	59 (26.5)
Painful urination	103 (8.9)	31 (7.8)	153 (28.3)	57 (25.6)
Lower abdominal pain	115 (10.0)	39 (9.8)	202 (37.4)	82 (36.8)
Vaginal itching	170 (14.7)	60 (15.0)	155 (28.7)	63 (28.5)
Dyspareunia	104 (9.0)	35 (8.8)	121 (22.4)	50 (22.4)
Vaginal sore	27 (2.3)	12 (3.0)	142 (26.3)	66 (29.6)
No. of sex partners in last month				
0	53 (4.6)	18 (4.5)	85 (15.7)	40 (17.9)
1	362 (31.4)	120 (30.1)	400 (74.1)	155 (69.5)
2+	739 (64.0)	261 (65.4)	55 (10.2)	28 (12.6)
Vaginal sex w/o condom past week w primary partner	638 (55.3)	202 (50.6)	190 (35.2)	78 (35.0)
Vaginal sex w/o condom past week w other partner	150 (13.0)	50 (12.5)	8 (1.5)	3 (1.3)

STI, sexually transmitted infection; w, with; w/o, without.

At baseline, women in the Bloemfontein study self-reported more risk behaviours than women in Rustenburg (table 1). Two-thirds of women in Bloemfontein reported vaginal intercourse with two or more partners in the month preceding cross-sectional screening; the corresponding percentage in Rustenburg was 14%. Over half of the women in Bloemfontein reported having vaginal intercourse with their primary partners without a condom in the previous week, whereas about a quarter of women in Rustenburg reported unprotected intercourse with primary partners in the previous week. Women in Bloemfontein were also more likely to report unprotected intercourse with a non-primary partner.

The baseline features of women who entered the prospective studies were broadly similar to those of the source screening populations at both sites (table 1), and there was little indication of selection for a particular subgroup into the prospective cohort.

HIV prevalence

In Bloemfontein cross-sectional screening, the HIV prevalence was 21.2% (95% CI 18.9% to 23.6%), overall: 13.4% in those 18–24 years, 38.1% in those 25–29 years and 37.1% in women aged 30–35 years (table 2). In Rustenburg, the overall HIV prevalence at screening was 23.5% (95% CI 19.9% to 27.1%) among women, ranging from 18.7% in those aged 18–24 years to 31.8% in those aged 25–29 years to 37.7% in those aged 30–35 years (table 2).

Factors associated with prevalent HIV

Three baseline factors were significantly associated with prevalent HIV infection at both study sites (table 3): age 30 or older compared with 18–24, less versus more educational attainment and living with a child versus not living with child. Self-reported signs or symptoms of STI were associated with HIV in Bloemfontein only, and

non-use of contraception versus use of condoms was associated with HIV in Rustenburg only. Sexual behaviour factors were not significantly associated with prevalent HIV infection.

HIV incidence

Nine seroconversions were observed during the prospective study in the Bloemfontein cohort, an overall incidence of 5.5/100 PY (95% CI 2.5 to 10.4; table 4). The incidence was 5.7/100 PY (95% CI 2.3 to 11.7) in women 18–24 years, 4.2/100 PY (95% CI 0.1 to 23.5) among women 25–29 years and 5.8/100 PY (95% CI 0.2 to 32.2) in the sparse 30–35 years age stratum.

Two seroconversions were detected in the Rustenburg cohort for an overall incidence of 3.0/100 PY (95% CI 0.4 to 10.8; table 4). Both seroconversions were in the 18–24 year age group, and the incidence in that younger age range was 4.0/100 PY (95% CI 0.5 to 14.5).

Ten of the 11 incident HIV infections at the two sites clearly occurred after enrolment in the prospective phase. One seroconversion in Bloemfontein was more problematic; rapid tests were negative at cross-sectional testing and no virus was detected in that stored specimen by PCR, but Western blot results were positive for the stored baseline specimen and were persistently blot positive until seroconversion at the 3-month visit. After excluding that Bloemfontein participant, the re-calculated Bloemfontein incidence rate was 4.9/100 PY (95% CI 2.1 to 9.6).

Factors associated with incident HIV

With nine new infections in the Bloemfontein cohort, we performed univariate proportional hazards regression with the same factors included in the analysis of risk factors for prevalent infection (above). No factor was significantly associated with incident infection. The strongest association with incident HIV was found for

Table 2 HIV prevalence among women in cross-sectional screening by age group and research site

	Bloemfontein	Rustenburg
Age 18–24		
Eligible population*, N	776	369
HIV positive, N	104	69
Prevalence (95% CI†)	13.4% (11.0% to 15.8%)	18.7% (14.7% to 22.7%)
Age 25–29		
Eligible population*, N	226	110
HIV positive, N	86	35
Prevalence (95% CI†)	38.1% (31.7% to 44.4%)	31.8% (23.1% to 40.5%)
Age 30+		
Eligible population*, N	143	61
HIV positive, N	53	23
Prevalence (95% CI†)	37.1% (29.1% to 45.0%)	37.7% (25.5% to 49.9%)
Total		
Eligible population*, N	1145	540
HIV positive, N	243	127
Prevalence (95% CI†)	21.2% (18.9% to 23.6%)	23.5% (19.9% to 27.1%)

*Eligible and had HIV test result.

†Approximate CI.

Table 3 Multivariable logistic regression analysis of factors associated with prevalent HIV among women screened in Bloemfontein and Rustenburg, South Africa

Factor	Bloemfontein OR (95% CI)	Rustenburg OR (95% CI)
Age 18–24 vs 30+	0.389 (0.243 to 0.623)	0.485 (0.284 to 0.826)
Age 24–29 vs 30+	1.222 (0.766 to 1.950)	0.844 (0.502 to 1.419)
Education: less than high school	2.240 (1.552 to 3.233)	1.979 (1.099 to 3.563)
Employed: yes	0.913 (0.587 to 1.419)	0.790 (0.509 to 1.227)
Living with child	1.569 (1.074 to 2.290)	2.078 (1.398 to 3.088)
Married	0.900 (0.541 to 1.498)	0.664 (0.304 to 1.450)
STI sign/symptom	2.081 (1.472 to 2.940)	1.071 (0.729 to 1.573)
Contraception: no method vs condom/other	1.395 (0.874 to 2.229)	2.056 (1.319 to 3.203)
Contraception: effective vs condom/other	0.777 (0.474 to 1.273)	1.321 (0.827 to 2.111)
More than 1 partner	1.250 (0.594 to 2.632)	1.425 (0.863 to 2.354)
1 or more new partner	1.168 (0.853 to 1.598)	1.136 (0.724 to 1.783)
More than 1 different partner	0.809 (0.564 to 1.161)	0.836 (0.504 to 1.387)
1 or more sex without condom with primary partner last month	1.279 (0.917 to 1.786)	1.165 (0.776 to 1.748)
1 or more sex without condom with any other partner last month	1.067 (0.622 to 1.831)	1.224 (0.444 to 3.379)
Anal sex with primary partner	0.828 (0.407 to 1.686)	0.974 (0.318 to 2.984)
Anal sex with any other partner	0.660 (0.183 to 2.383)	1.333 (0.153 to 11.577)

Significant factors are in bold-face.
STI, sexually transmitted infection.

one or more unprotected coital acts with a non-primary partner in the last month (HR=6.7; p=0.07).

Pregnancy

The prevalence of pregnancy at the time of cross-sectional screening was 6.5% (95% CI 5.0% to 7.9%) in Bloemfontein and 8.6% (95% CI 6.2% to 10.9%) in Rustenburg. (Further analysis of the Rustenburg pregnancy results will appear elsewhere.) In Bloemfontein, the pregnancy prevalence in screened women ranged from 11.0% (95% CI 8.5% to 14.0%) in those not using a method to 3.5% (95% CI 1.3% to 7.5%) in condom users and 2.1% (95% CI 0.9% to 3.9%) in users of effective methods (hormonal and IUCDs). The Bloemfontein pregnancy incidence was 16.4/100 PY (95% CI 10.8 to 23.9) and ranged from 27.6/100 PY (95% CI 17.1 to 42.2) in women not using a method at baseline to 12.4/100 (95% CI 2.6 to 36.4) in condom users and 4.7/100 (95% CI 1.0 to 13.7) in users of effective methods (hormonal or IUCD).

DISCUSSION

HIV prevalence in Bloemfontein's Free State Province has been close to 30% in antenatal surveillance for several years. Prevalence was lower in this study, at 21.2%, yet we detected a high incidence rate of 5.5/100 PY in the overall cohort. We observed similar HIV incidence across the age spectrum in the Bloemfontein cohort, contrary to national estimates.⁸ The HIV prevalence among Rustenburg women in the cross-sectional screening was 23.5%, again lower than recent antenatal surveillance data from the area, which could be explained by the young average age of the cohort screened. The prospective incidence rate in the Rustenburg cohort was 3.0/100 PY and higher among younger women (4.0/100 PY in 18–24 year olds).

National household survey data in South Africa show that HIV prevalence has stabilised and suggest that the incidence estimated from nationally representative surveys has declined in younger age groups.⁸ But the overall estimated incidence remained 1.3/100 uninfected persons of reproductive age from 2005 to 2008.⁸ Others have described a pattern of stable prevalence in South African antenatal surveillance and population-based surveys coupled with substantial incidence rates in defined cohorts.⁹ In the relatively few studies that have directly measured HIV incidence, it has been distressingly high in both urban and rural sites, despite multiple follow-up contacts, ongoing risk-reduction counselling and condom promotion and provision. Between 2001 and 2004, a representative cohort in one part of rural Limpopo Province had an HIV incidence of 4.9/100 PY among women, despite self-reported increases in condom use during that period.¹⁰ In the HPTN 055 cohort study, the two South African sites, both located in Kwa-Zulu Natal Province, had the highest HIV incidence rates in 2003–2004 (Durban 5.3/100 PY and Hlabisa 6.2/100 PY).¹¹ In 2004–2007, the HIV incidence rate was 6.4/100 PY and 6.5/100 PY in an urban and a rural cohort in KwaZulu-Natal, respectively.⁹ Three recent randomised trials of ineffective prevention products have also reported substantial HIV incidence at their South African sites.^{12–14} Finally, a cohort study conducted between 2007 and 2009 at two sites in Northwest Province and Western Cape Province for capacity-building purposes reported 12-month incidence rates of 6.0/100 PY and 4.5/100 PY, similar to the rates reported here.¹⁵

Older participants had a higher risk of prevalent HIV infection in our study than younger, reflecting their longer potential for exposure to HIV. Lesser education was also associated with baseline HIV infection, as has

Table 4 HIV incidence among women in the prospective study at the Bloemfontein and Rustenburg sites

	Bloemfontein	Rustenburg
Number with HIV test result during follow-up	391	194
Confirmed HIV seroconversions	9	2
Person-years of follow-up	164.4	67.1
Incidence rate* (95% CI†)	5.5 (2.5 to 10.4)	3.0 (0.4 to 10.8)

*Per 100 person-years.

†Exact CI.

been found in other South African studies.^{10 16} Other factors were not consistently associated with baseline infection across the sites, which may stem from unmeasured sexual network factors and misclassification error resulting from self-report. In fact, the striking differences in the self-reported risk behaviours between these two cohorts suggest that some self-reporting bias may have occurred. Bloemfontein participants reported high rates of multiple partnering (about two-thirds of the women) compared with national data on South African women aged 15–49 years (3.7% in 2008) and data on men and women in the Free State in the same 2008 survey (14.6%).¹⁷ In contrast, reports of multiple partnering at the Rustenburg site were close to national averages (12%–14%) and similar to a prior representative household survey in Rustenburg.¹⁸

One weakness of our analysis is that, partly due to the relatively short follow-up period, there were too few seroconversion events to do multivariable proportional hazards regression, and our univariate regression results for incident HIV infections were necessarily inconclusive. A limitation of the analysis of risk factors for prevalent HIV infections is that the behaviours reported at screening may not have reflected behaviours present at the time of infection. Lack of STI diagnostic testing precluded evaluating associations with other infections.

Perhaps the greatest study weakness relates to the validity of self-reported sexual behaviours, both for purposes of determining eligibility as well as for assessing risk during follow-up. The inaccuracies in self-reported sexual behaviour during research interviews have been amply documented and are not unique to these studies. Although we attempted to keep the eligibility factors secret from participants and outreach staff, we do not know if volunteers (both eligible and ineligible) guessed those factors and shared them with other women in the community. There may have been an awareness among women at the Bloemfontein site in particular to over-report risky behaviours to gain entry to the study: the eligibility rate was very high there and risk behaviours far exceeded national estimates. Alternatively, recruiters at the Bloemfontein, but not the Rustenburg, site may have

simply tapped into a subgroup of women with particularly risky behaviour. During baseline and follow-up interviews with participants, however, we did not observe strong associations between those same behavioural factors and HIV infection.

Our study cohorts cannot be considered representative of young women in the two cities. Our behavioural eligibility criteria selected for a group of women with higher than average risk behaviours. The Rustenburg site offered the opportunity to demonstrate the impact of these selection factors: a representative household survey had been done there in 2008, 1 year before our study commenced. Our study cohort was younger, better educated, less likely to be employed and less likely to be married or live with a steady partner than all Rustenburg community residents. Most critically, only 3.4% of women in the household survey reported multiple sexual partners in the past 3 months compared with over 10% of women screened in our study who reported multiple partners in the past 1 month. So we make no claims for representativeness: our project deliberately set out to identify and follow a cohort with higher than average risk behaviours, in order to demonstrate the suitability of the sites for future prevention research.

Countervailing study strengths include the longitudinal design with high retention rates. Classification of the HIV outcome was highly accurate, using multiple monthly rapid tests confirmed by later PCR testing. Testing of stored baseline specimens allowed us to pinpoint seroconversion and rule out acute prestudy infections. Finally, direct prospective measurement of HIV infection circumvented the lingering issues with the accuracy of cross-sectional incidence estimation.

The high HIV prevalences and incidence rates in these cohorts in two smaller South African cities should spur vigorous HIV prevention efforts. The need for HIV care and treatment in these areas is clear, and while care is available, Free State Province experienced stock-outs of HIV antiretroviral drugs during the study.¹⁹

Our results also highlight the success of the collaborative capacity-building SIDI projects: these sites are highly suitable and ready for HIV prevention research and programming. Both sites added staff and were provided broad research training, and these new skills were immediately applied in a rigorous clinical research study. Dealing with local ethics committees and community stakeholders, recruiting and enrolling potentially higher risk women, administering informed consent, bringing participants back for regular study visits, giving ongoing risk reduction and HIV counselling and making referrals for continued healthcare, all within the context of Good Clinical Practice, mimicked future prevention trials. At the conclusion of its study, JOSHA in Bloemfontein was selected to implement an oral HIV prophylaxis trial. The Aurum Institute in Rustenburg is currently conducting a trial of a vaginal microbicide, along with other behavioural HIV studies. The national research capacity has been boosted and diffused to new sites

outside the larger cities, which can only be a boon for future HIV and other clinical research in South Africa.

Acknowledgements We thank the study participants, the study teams at The Aurum Institute and JOSHA, staff at PathCare Laboratories and at the Mangaung-University Community Partnership Program in Bloemfontein and the Departments of Health in North West and Free State Provinces. Sharne Foulkes, Ilse Reblin and Gustav Venter were vital to study success in Bloemfontein. We are also grateful to FHI 360 colleagues Lydia Mugo and Melissa Polier for clinical monitoring, Lisa Saylor for data management training and support and Sola Park for statistical support, as well as the helpful reviews of our FHI 360 colleagues and journal reviewers.

Contributors PJF, MHL, JL, CC, P-LC and CS contributed to the design of the study and its essential documents. MHL, JL and CC led data collection. PJF, MHL, JL, P-LC, CS and SF contributed to the analysis and interpretation of the data. PJF, MHL, JL, CC and SF drafted the article. All authors approved the final version of the manuscript.

Funding This work was funded by the US Agency for International Development (USAID) under Cooperative Agreement No. GPO-A-00-05-00022-00 and the Contraceptive and Reproductive Health Technologies Research and Utilisation (CRTU) Program. Additional funding was provided by the Centers for Disease Control and Prevention (CDC) under contract no. 200-20074-05314, Task Order #7. The contents are the responsibility of FHI 360 and do not necessarily reflect the views of USAID or the CDC.

Competing interests None.

Ethics approval FHI 360 Protection of Human Subjects Committee; University of the Free State Ethics Committee; University of KwaZulu-Natal BREC.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional unpublished data will be available.

REFERENCES

1. Joint United Nations Programme on HIV/AIDS and World Health Organization. Geneva: AIDS Epidemic Update, 2009.
2. Karim QA, Karim S, Frohlich J, *et al.* Effectiveness and safety of tenofovir gel, an antiretroviral microbicide, for the prevention of HIV infection in women. *Science* 2010;329:1168–74.
3. Grant RM, Lama JR, Anderson PL, *et al.* Pre-exposure chemoprophylaxis for HIV prevention in men who have sex with men. *N Engl J Med* 2010;363:2587–99.
4. Auvert B, Taljaard D, Lagarde E, *et al.* Randomized, controlled intervention trial of male circumcision for reduction of HIV infection risk: the ANRS 1265 trial. *PLoS Med* 2005;2:e298.
5. Bailey RC, Moses S, Parker CB, *et al.* Male circumcision for HIV prevention in young men in Kisumu, Kenya: a randomised controlled trial. *Lancet* 2007;369:643–56.
6. Republic of South Africa Department of Health. *National Antenatal Sentinel HIV and Syphilis Prevalence Survey in South Africa, 2009*. Pretoria: Department of Health, 2010.
7. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Soc Probl* 1997;44:174–99.
8. Rehle TM, Hallett TB, Shisana O, *et al.* A decline in new HIV infections in South Africa: estimating HIV incidence from three national HIV surveys in 2002, 2005 and 2008. *PLoS ONE* 2010;5:e11094.
9. Karim QA, Kharsany ABM, Frolich JA, *et al.* Stabilizing HIV prevalence masks high HIV incidence rates amongst rural and urban women in KwaZulu-Natal, South Africa. *Int J Epidemiol* 2011;40:922–30.
10. Hargreaves JR, Bonell CP, Morison LA, *et al.* Explaining continued high prevalence in South Africa: socioeconomic factors, HIV incidence and sexual behavior change among a rural cohort. *AIDS* 2007;21(Suppl 7):S39–48.
11. Ramjee G, Kapiga S, Weiss S, *et al.* The value of site preparedness studies for future implementation of Phase 2/IIb/III HIV prevention trials: experience from the HPTN 055 study. *J Acquir Immune Defic Syndr* 2008;47:93–100.
12. Skoler-Karpoft S, Ramjee G, Ahmed K, *et al.* Efficacy of Carraguard for prevention of HIV infection in women in South Africa: a randomised, double-blind, placebo-controlled trial. *Lancet* 2008;372:1977–87.
13. Padian NS, van der Straten A, Ramjee G, *et al.* Diaphragm and lubricant gel for prevention of HIV acquisition in Southern African women: a randomised controlled trial. *Lancet* 2007;370:251–61.
14. Gray GE, Allen M, Moodie Z, *et al.* Safety and efficacy of the HVTN 503/Phambili Study of a clade-B-based HIV-1 vaccine in South Africa: a double-blind, randomized, placebo-controlled test-of-concept phase 2b study. *Lancet Infect Dis* 2011;11:507–15.
15. Nel A, Louw C, Hellstrom E, *et al.* HIV prevalence and incidence among sexually active females in two districts of South Africa to determine microbicide trial feasibility. *PLoS One* 2011;6:e21528.
16. Johnson LF, Dorrington RE, Bradshaw D, *et al.* The effect of educational attainment and other factors on HIV risk in South African women: results from antenatal surveillance, 2000-2005. *AIDS* 2009;23:1583–8.
17. Shisana O, Rehle T, Simbayi LC, *et al.* *South African National HIV Prevalence, Incidence, Behaviour and Communication Survey 2008: A Turning Tide Among Teenagers?* Cape Town: HSRC Press, 2009.
18. Latka MH, Meyer-Weitz A, Fielding K, *et al.* *Factors Associated With Concurrent Sexual Partnering And Condom Use Are Not The Same: Results From A Representative Household Survey in Rustenburg*. Durban, South Africa: Poster presented at South African AIDS Conference, 2009.
19. El-Khatib Z, Richter M. (ARV-) Free state? The moratorium's threat to patients' adherence and the development of drug-resistant HIV (letter). *S Afr Med J* 2009;99:412–14.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5, 8
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	5, 10
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
			8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	8-10
			8
Outcome data	15*	Report numbers of outcome events or summary measures over time	11, 14
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-13
			12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11, 14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-16
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

* Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.