High HIV Prevalence Among Men Who have Sex with Men in Soweto, South Africa: Results from the Soweto Men's Study

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Abstract The Soweto Men's Study assessed HIV prevalence and associated risk factors among MSM in Soweto, South Africa. Using respondent driven sampling (RDS) recruitment methods, we recruited 378 MSM (including 15 seeds) over 30 weeks in 2008. All results were adjusted for RDS sampling design. Overall HIV prevalence was estimated at 13.2% (95% confidence interval 12.4–13.9%), with 33.9% among gay-identified men, 6.4% among bisexual-identified men, and 10.1% among straight-identified MSM. In multivariable analysis, HIV infection was associated with being older than 25 (adjusted odds ratio (AOR) 3.8, 95% CI 3.2–4.6), gay self-identification (AOR 2.3, 95% CI 1.8–3.0), monthly income less than ZAR500 (AOR 1.4, 95% CI 1.2–1.7), purchasing alcohol or drugs in exchange for sex with another man (AOR 3.9, 95% CI 3.2–4.7), reporting any URAI (AOR 4.4, 95% CI 3.5–5.7), reporting between six and nine partners in the prior 6 months (AOR 5.7, 95% CI 4.0–8.2), circumcision, (AOR 0.2, 95% CI 0.1–0.2), a regular female partner (AOR 0.2, 95% CI 0.2–0.3), smoking marijuana in the last 6 months (AOR 0.6, 95% CI 0.5–0.8), unprotected vaginal intercourse in the last 6 months (AOR 0.5, 95% CI 0.4–0.6), and STI symptoms in the last year (AOR 0.7, 95% CI 0.5–0.8). The results of the Soweto Men's Study confirm that MSM are at high risk for HIV infection, with gay men at highest risk. HIV prevention and treatment for MSM are urgently needed.

Keywords Africa · Men who have sex with men · Gay men · HIV prevalence · Risk factors

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Introduction

Although men who have sex with men (MSM) have been disproportionately affected by HIV since the beginning of the epidemic, research on the epidemiology of HIV among MSM populations MSM in sub-Saharan Africa is just beginning [1, 2]. Published studies of MSM from Botswana, Malawi, Namibia, Senegal, South Africa, and Uganda have noted high rates of unprotected anal intercourse (UAI) between men [3–6]. In addition, the Senegal survey and VCT data from Kenya [7] report HIV prevalence figures for MSM much higher than their corresponding national prevalence estimates. A recent meta-analysis found African MSM are nearly four times more likely to be HIV infected than the general population [8]. Despite these findings, many African countries have yet to include MSM among their most at-risk populations in national HIV planning. Moreover, homosexuality is illegal in much of Africa. Lack of HIV data and criminalization of homosexuality may reinforce each other, keeping the full extent of the HIV epidemic among MSM from being addressed [9]. South Africa is an exception to this trend. Homosexuality was decriminalized in 1994, and more recently the country has included MSM in its 2007–2011 HIV and STI National Strategic Plan [10]. Nonetheless, even South Africa's

response to the HIV prevention and treatment needs of MSM has suffered from a lack of behavioral and HIV prevalence data.

While some population-based surveys have found increased risk of HIV infection among men who report same-sex behavior [11], most behavioral and epidemiological studies with African MSM as the target population have relied on convenience or snowball samples of men who self-identify as homosexual within their cultural contexts [3, 5, 12–14]. While these studies have been an important to beginning investigations of the HIV epidemic among MSM where same sex behavior is stigmatized or illegal, more hidden, non-homosexually identified subpopulations of MSM may be underrepresented in these samples. The sexual behaviors and HIV prevalence of such men are important to understanding patterns of HIV transmission among MSM generally. Furthermore, selection bias limits the generalizability of results. The respondent driven sampling (RDS) methodology described by Heckathorn has the potential to reach more deeply into hidden MSM sub-populations and, by limiting recruitment and tracking the personal network size of participants, to minimize biases inherent in convenience and snowball sampling [15, 16]. To date, only one published study of MSM in Africa has used RDS recruitment and estimation, but it was not able to measure HIV prevalence [4].

This paper presents results from The Soweto Men's Study, which assessed HIV prevalence and risk factors in a population of sexually active MSM in Soweto, South Africa, using RDS recruitment and analysis methods. Soweto is a peri-urban "township" roughly 15 km southwest of central Johannesburg with a population estimated between 1.5 and 3 million. The MSM population includes men who openly identify as "gay" or "bisexual", as well as many who identify as "straight" to keep their same-sex behaviors hidden from family, friends, or female partners. It is important to note that the "gay" identity claimed by Soweto MSM does not map neatly onto "western" or "global" gay identity as it is commonly understood. In preliminary ethnographic work, MSM associated gay identity with feminine gender identity—though it is important to note that "transgender" is not an identity category that any of our participants claimed.

The study took place at the University of the Witwatersrand's (Wits) Perinatal HIV Research Unit (PHRU) at Chris Hani-Baragwanath Hospital. PHRU and the University of California San Francisco's (UCSF) Center for AIDS Prevention Studies have collaborated on MSM HIV research since 2003. Unlike South Africa's other major urban centers (Cape Town, Durban, and Pretoria), no lesbian-gay-bisexual-transgender (LGBT) organization was working on HIV prevention activities with the Soweto MSM population at the time of our study.

Methods

The Soweto Men's Study sampled sexually active MSM who lived, worked, or socialized in Soweto. To begin RDS recruitment, we purposively selected 15 seeds that were diverse with respect to sexual identity, HIV status, and geographic distribution within Soweto. These seeds recruited additional MSM from their social networks using study coupons pre-printed with the Study's phone number and location. Staff screened recruits for eligibility in the study office. Participants were eligible if they were over age 18; lived, worked, or socialized in Soweto; had engaged in oral or anal intercourse with another man in the prior 6 months; had a valid study coupon and had not previously participated in the study; and were able to provide written informed consent. The study was approved by Wits's Human Research Ethics Committee and UCSF's Committee on Human Research.

The study questionnaire was based on a behavioral instrument used previously with this population [5]. Questions included standard demographic indicators; regular female and male sexual partnerships (someone the participant "lived with, saw a lot, and felt a special emotional commitment to for 3 months or more"); circumcision status; history of incarceration; age and condom use at sexual debut with men and women; history of coerced sex; transactional sex with men and women (sex in exchange for "expensive gifts," "money, food, or a place to sleep," and "drugs or alcohol"); and drug and alcohol use. The Alcohol Use Disorders Identification Test (AUDIT) was used to characterize drinking behavior [17]. AUDIT assessments include frequency of drinking, amount of alcohol consumed when drinking, and perceptions of self and others about drinking; a score greater than 9 indicates "problem drinking." The survey also asked partner-by-partner sexual behavior and condom use questions for up to five partners within the prior 6 months. Participants reported the sex of their partners (and sexual identity of male partners), whether regular (e.g. husband/wife, boyfriend/girlfriend) or casual (e.g. "one night stand"), number of times vaginal or anal sex, position in anal sex, and number of protected acts. Unprotected sex (vaginal and anal) was determined by subtracting number of protected sex acts from number of sex acts; all responses greater than zero were coded unprotected. Finally, participants answered questions about their history of STI symptoms and treatment in the last 12 months, HIV testing history, and perceived HIV status.

HIV status was determined through rapid antibody testing on blood samples collected through voluntary counseling and testing (VCT), linked to the participants' behavioral data by study identification number. After completing the survey, we offered all participants VCT, for

which they provided separate informed consent. Trained counselors provided pre- and post-test counseling. After pre-test counseling, a nurse drew 5 ml of blood from each participant. Participants could elect to receive their results that day, or to return within 3 months of their study visit. Men who received a positive result were referred to clinical care within the PHRU pending the result of CD4 testing of their blood samples. Men with CD4 cell counts less than 200/mm^3 were provided with antiretroviral (ARV) treatment free of charge.

Laboratory Procedures

We followed the South African national standard algorithm for serial rapid testing. All samples were first tested on Determine (Abbott Laboratories, Abbott Park, IL) rapid test kits. Non-reactive samples were interpreted as HIV-negative. Reactive samples were then tested using Uni-Gold (Trinity Biotech, Wicklow, Ireland) rapid test kits. Uni-Gold reactive samples were confirmed as positive. Uni-Gold non-reactive samples were interpreted as indeterminate and sent to the National Health Laboratory Services (NHLS) lab in Johannesburg for confirmatory testing. Additionally, confirmed positive samples were sent to the NHLS lab for CD4 testing.

Data analysis

We estimated HIV and behavioral risk factor prevalence using RDSAT software version 5.6 (www.respondent drivensampling.org) which adjusted for personal network size and homophily in recruitment. In general, larger personal network sizes and a high degree of homophily would adjust the crude sample proportion downward; by comparison, smaller network sizes and less homophily in recruitment would adjust the crude proportion upward. Demographic and behavioral variables were analyzed in relation to HIV result as the main outcome of interest. RDSAT also provided individual HIV outcome weights for use in multivariable analyses following methods outlined by Heckathorn [18]. Multivariable analyses were conducted (weighted by RDSAT-generated HIV result weights) in SAS version 9.1 (Cary, NC).

Seventy-one participants declined VCT and were thus missing the main outcome of interest. Because RDS analysis takes into account network size and homophily to produce population estimates, declaring the data "missing" would have, in effect, broken the recruitment chains and networks in which these participants were embedded. To preserve our ability to produce estimates using RDS outcome weights, we used multiple imputation to account for missing HIV status. To select variables on which to base the imputation, we first explored bivariate demographic

and behavioral predictors of HIV infection in the crude data at $P < 0.05$ level. We then constructed a saturated multivariable model using these variables with HIV status as the outcome, and used likelihood ratio testing to develop a restricted model including all variables at $P < 0.10$. Next, a logistic regression using the -mim- command in Stata 9.0 (College Station, TX) was run 20 times using a randomly chosen seed to produce 20 separate datasets with imputed values for the 71 missing HIV results. These 20 datasets were then individually exported into RDSAT, which assigned individualized HIV outcome weights to each observation in each dataset. The weights were then merged into their corresponding datasets by participant identification number. Finally, the 20 datasets were stacked in Stata using the -mimstack- command, producing a single dataset with imputed values for all missing HIV results. To ensure that the imputed results were within the boundaries of the two extreme possibilities of all missing results being either negative or positive, we compared HIV prevalence, bivariate associations, and multivariable logistic regression analyses of the imputed results to the two alternative scenarios using the RDSAT generated weights. Each multivariable model included variables associated with HIV infection in any of the three bivariate scenarios at $P < 0.10$.

Results

Recruitment took place over 30 weeks between February and August 2008, and produced a crude sample of 378 MSM. Demographic and sexual identity indicators are presented in Table 1. In adjusted analysis of 363 non-seed respondents, 16.1% identified as gay, 33.6% as bisexual, and 43.2% as straight. All of South Africa's black African ethnic groups were represented in the sample, and all but one participant were black South Africans. Circumcision prevalence was 36.4%, and a majority reported regular partnerships with women (63.4%) or men (69.6%).

Alcohol was the most commonly used substance (Table 2), with 87.9% reporting that they drank at least once per month, and 54.5% reporting 10 or more drinks on a typical day of drinking; 75.9% of AUDIT scores indicated problem drinking. Other substance use was less common; 25.0% of the sample had used marijuana, and use of stimulants including ecstasy, cocaine, methcathinone, and methamphetamines was rare, as was injection drug use.

Sexual health indicators for this population were mixed. Few reported STI symptoms in the last year. Although 37.9% had ever tested, recent HIV testing (i.e. within the last 6 months) was uncommon. Prior to testing in the study, most men perceived that they were HIV-negative (57.2%); less than 1% of MSM perceived that they were HIV-positive.

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Table 1 Crude and population-adjusted demographic indicators of MSM in Soweto Men's Study (N = 363)

Variable	Crude[a] % (N)	Adjusted % (95% CI)
Age (median 23, range 18–48)		
18–24	64.0 (235)	69.0 (60.6–75.6)
25 and older	36.0 (128)	31.0 (24.4–39.4)
Education		
Primary	1.9 (7)	2.3 (0.7–4.3)
Secondary	79.4 (280)	83.6 (76.6–87.6)
Post-secondary	18.8 (64)	14.2 (10.3–21.2)
Residence		
Soweto	99.5 (362)	99.7 (99.0–100)
Other Johannesburg	0.5 (1)	0.3 (0.1–0.7)
Monthly income in rand (7 rand–1 USD)		
<R500	77.5 (281)	76.6 (70.7–84.0)
R500–999	5.8 (20)	7.2 (2.4–10.3)
R1000–4999	13.8 (51)	12.8 (8.1–17.9)
R5000–9999	2.1 (8)	2.9 (0.6–6.3)
≥R10000	1.1 (3)	0.4 (0–1.6)
Employment		
Unemployed	64.8 (235)	62.3 (55.4–69.7)
Student	14.6 (55)	18.2 (12.6–25)
Laborer	4.5 (16)	3.4 (1.7–5.6)
Shopkeeper	1.1 (4)	1.3 (0.1–2.7)
Clerical	1.1 (3)	0.1 (0.0–0.2)
Professional	6.1 (22)	2.1 (0.1–3.8)
Other	7.9 (28)	12.6 (6.8–17.2)
Sexual identity		
"Gay"	34.1 (120)	16.1 (11.3–22.2)
"Bisexual"	30.4 (112)	33.6 (28.1–41.4)
"Straight"	31.7 (118)	43.2 (35.5–50.9)
Regular female partner		
Yes	51.2 (186)	63.4 (55.9–70.8)
No	48.8 (177)	36.6 (29.3–44.1)
Regular male partner		
Yes	73.0 (265)	69.6 (64.7–76.7)
No	27.0 (98)	30.4 (23.3–35.3)
Circumcision status		
Circumcised	33.6 (124)	36.4 (30.0–44.8)
Uncircumcised	66.1 (238)	62.8 (52.8–69.4)
Not sure	0.3 (1)	0.7 (0–1.6)
Ever been in prison		
Yes	21.7 (80)	21.5 (16.2–27.0)
No	78.3 (283)	78.5 (73.0–83.8)

[a] Sub-groups do not always add up to totals due to missing data

The unadjusted results of HIV testing showed that 20.6% of the sample was HIV-positive, with 18.8% declining to give a blood sample; of the 307 men who consented to VCT, 115 (37.5%) declined to receive their results on the day of their study visit, and none returned within 6 months to collect them.

Our multiple imputation procedure suggested that most of the missing HIV results were negative. Based on this imputation, we present adjusted results of bivariable analyses in Table 3, and multivariable analyses in Table 4. The overall HIV prevalence estimate for this MSM population is 13.2% (95% confidence interval (CI) 12.4–13.9%), with 33.9% among gay-identified men, 6.4% among bisexual-identified men, and 10.1% among straight-identified MSM. Significant bivariate predictors of HIV infection were age (25 or older), gay identity, monthly income greater than ZAR 500, having a regular male partner, purchasing alcohol or drugs for a male partner in exchange for sex, ever having receptive anal intercourse (RAI) with another man, and reporting unprotected insertive (UIAI) or receptive anal intercourse (URAI) with male partners within the last 6 months. HIV infection was significantly less likely among MSM who were circumcised, smoked marijuana within the prior 6 months, had a regular female partner, and reported unprotected vaginal intercourse (UVI) with women. In multivariable analysis, increased odds of infection was associated with age (adjusted odds ratio (AOR) 3.8, 95% CI 3.2–4.6), gay identity (AOR 2.3, 95% CI 1.8–3.0), monthly income less than ZAR500 (AOR 1.4, 95% CI 1.2–1.7), purchasing alcohol or drugs in exchange for sex with another man (AOR 3.9, 95% CI 3.2–4.7), reporting URAI (AOR 4.4, 95% CI 3.5–5.7), and reporting between six and nine partners in the prior 6 months (AOR 5.7, 95% CI 4.0–8.2). Decreased risk of HIV infection was associated with being circumcised, (AOR 0.2, 95% CI 0.1–0.2), having a regular female partner (AOR 0.2, 95% CI 0.2–0.3), having smoked marijuana in the last 6 months (AOR 0.6, 95% CI 0.5–0.8), UVI with women (AOR 0.5, 95% CI 0.4–0.6), and reporting STI symptoms in the last year (AOR 0.7, 95% CI 0.5–0.8).

Discussion

The results of the Soweto Men's Study confirm that MSM are at high risk for HIV infection, and demonstrate that HIV is unevenly distributed among MSM subpopulations. At 33.9%, HIV prevalence among self-identified gay men is greater than three times that of bisexual and straight-identified MSM, whose respective estimates of 6.4 and 10.6% are comparable to the 11.7% HIV prevalence found among South African men aged 15–49 in the 2005 national survey [19]. In their meta-analysis of HIV prevalence for MSM in developing countries, Baral et al. found MSM in Africa were 3.8 times more likely to be HIV infected than the general population [8], yet our overall prevalence estimate of 13.2% is comparable to men in the general population. However, as the samples from which Baral

Table 2 Crude and adjusted HIV behavioral, substance use, sexual health, and HIV prevalence indicators of MSM in Soweto Men's Study (N = 363)

Variable	Crude[a] % (N)	Adjusted % (95% CI)
Sexual behavior		
Sexual history with women		
Ever vaginal sex with women	71.1 (261)	86.5 (79.7–91.2)
Ever exchange sex with women		
Received expensive gifts	31.8 (73)	30.8 (23.6–38.0)
Received money, food, place to sleep	47.0 (101)	44.5 (35.2–51.5)
Received drugs/alcohol	37.5 (86)	39.2 (32.2–50.8)
Provided expensive gifts	39.0 (88)	35.8 (28.5–44.9)
Provided money, food, place to sleep	54.3 (120)	52.6 (44.4–60.7)
Provided drugs/alcohol	49.1 (111)	50.9 (45.0–59.8)
Report female partners in past 6 months	48.7 (179)	60.9 (53.2–68.1)
Any unpro vag with female partner (UVI)	37.8 (140)	45.6 (38.1–53.1)
Any anal with female partner	11.9 (44)	16.3 (10.9–21.8)
Any unpro anal with female partner	4.8 (18)	8.8 (4.8–13.3)
Sexual history with men		
Ever insertive anal sex	76.7 (282)	86.0 (80.2–90.8)
Ever receptive anal sex	45.6 (161)	30.3 (23.5–37)
Ever exchange sex with men		
Received expensive gifts	36.5 (132)	34.7 (28.1–40.6)
Received money, food, place to sleep	48.4 (175)	49.4 (40.9 54.3)
Received drugs/alcohol	49.2 (179)	44.9 (37.1–51.2)
Provided expensive gifts	15.1 (54)	9.5 (5.8–11.2)
Provided money, food, place to sleep	24.3 (86)	21.8 (15.7–26.7)
Provided drugs/alcohol	23.0 (81)	17.9 (12.9–21.2)
IAI with male partners (ever)	77.7 (282)	85.2 (78.6–90.6)
Any UIAI with male partners (6 mo)	28.6 (103)	28.0 (21.9–33.6)
RAI with male partners (ever)	37.8 (135)	20.6 (15.5–27.0)
Any URAI with male partner (6 mo)	17.5 (61)	9.5 (6.5–14.2)
Ever been coerced into sex	21.7 (76)	16.0 (10.8–21.3)
Substance use		
How often do you drink alcohol?		
Never	11.1 (41)	12.1 (7.5–17.3)
Once per month	29.6 (108)	28.8 (23.0–36.1)
2–4 times per month	32.3 (116)	31.5 (24.0–36.9)
2–3 times per week	19.3 (69)	17.3 (13.0–23.7)
4 or more times per week	7.7 (29)	10.3 (5.9–14.8)
Problem drinking (AUDIT > 9)	75.7 (276)	75.9 (70.0–82.1)
Drug use: used in last 6 months		
Marijuana ("dagga")	26.5 (96)	25.0 (20.6–30.8)
Cocaine	1.3 (5)	0.5 (0.1–1.2)
Ecstasy	4.0 (14)	2.0 (0.8–3.7)
Crystal methamphetamine ("tik")	0.3 (1)	0.5 (0.0–1.6)
Methcathinone ("khat")	0.3 (1)	0.2 (–)
Heroin	1.1 (4)	1.9 (0.5–3.6)
Methaqualone (mandrax)	1.9 (7)	0.9 (0.3–1.7)
Nyaupe	1.3 (5)	2.7 (0.5–5.8)
Gamma hydroxy-butyrate (GHB)	0.3 (1)	0.0 (0.0–0.1)
Ever injected illicit drugs	0.5 (2)	2.1 (0.0–2.6)

Table 2 continued

Variable	Crude[a] % (N)	Adjusted % (95% CI)
Sexual health and HIV		
Any STI symptoms (12 months)	25.9 (98)	28.0 (26.3–29.7)
Ever HIV test	43.5 (158)	37.9 (30.6–45.1)
Perceived HIV status today		
Negative	56.6 (188)	57.2 (48.0–62.2)
Positive	2.4 (8)	0.8 (0.2–1.5)
Don't know/no answer	40.4 (134)	41.1 (35.7–49.4)
HIV status		
Negative	60.6 (224)	69.0 (63.0–76.2)
Positive	20.6 (69)	10.9 (6.5–14.6)
Declined to test	18.8 (70)	20.1 (14.0–26.6)

[a] Sub-groups do not always add up to totals due to missing data

et al.'s pooled estimates were drawn were largely derived from convenience samples of men who self-identified as gay or another homosexual identity and were not adjusted for sampling designs, our finding that gay-identified men have a substantially higher odds of HIV infection than non-gay identified MSM is largely consistent with the findings of the meta-analysis.

In reporting this finding, we recognize that gay identity is not a behavior, although in township MSM communities gay identity is itself highly correlated with the exclusive practice of RAI, and conversely, self-identifying as bisexual or a straight MSM was highly correlated with the exclusive practice of insertive anal intercourse (IAI) with male partners [5]. Since gay-identified men are also the most visible of MSM in township communities, this finding indicates that it is possible and necessary to begin working immediately with gay-identified men on HIV prevention and treatment, focused not only on individual behaviors, but the disadvantageous structural and socio-cultural contexts that influence their behaviors. Unlike other sub-Saharan African countries, there are no legal barriers to working with gay communities in South Africa.

The Soweto Men's Study is also, to our knowledge, one of the first studies of MSM in Africa to have applied the RDSAT-generated weight outcomes described by Heckathorn [18] to estimate HIV prevalence and to develop multivariable model of HIV risk factors, and the first with an HIV prevalence outcome to account for missing outcome data through multiple imputation. That the imputed model's HIV prevalence estimates were between the two extreme possibilities gives us confidence that the procedure has resulted in a reasonable initial HIV prevalence estimate for this population. Given RDS's popularity with studying MSM populations in sub-Saharan Africa, future behavioral and HIV surveillance studies using RDS may need to follow similar procedures to account for missing HIV data. Other studies have found that MSM who are socially

vulnerable may be reluctant to test [12], and that many MSM have prior negative experiences with HIV VCT [20]. It is therefore understandable that MSM may decline to test even in a study setting that guaranteed access to medical care.

Several studies have noted the association between alcohol consumption and sexual risk behaviors [21–23] Our sample was quite homogenous in its drinking behavior, and thus we did not detect a statistically significant association with UAI or HIV infection; we do not conclude that alcohol consumption plays no part in HIV transmission among MSM. On the contrary, purchasing alcohol in exchange for sex with other men predicted HIV infection— and was the only form of transactional sex between men with a significant effect. This speaks to the complex role that substance use and sexual exchange play in the lives of township MSM. Better understanding how all of these factors may contribute to MSM's HIV risk will be important to intervention efforts.

A large number of participants also reported having a regular female partner, and counted at least one woman among their last five partners. Although female partnerships and UVI were associated with lower HIV risk, the comparison group in each case is composed overwhelmingly of gay-identified men who practice RAI with other men, whose risk is much higher. It is important to note that relatively high rates of self-reported UVI (45.6%) and UIAI with men (28.0%) in this population provide ample opportunity for HIV transmission to take place, and suggests that the heterosexual and MSM epidemics are behaviorally linked. MSM who also have sex with women keep their identities and behaviors hidden and are therefore difficult to target with same-sex specific HIV prevention messaging aimed at gay men; in the absence of information this group may be inadvertently increasing the long-term risk of HIV infection to themselves as well as their male and female partners.

Table 3 Adjusted bivariate associations between selected risk variables and HIV infection (using RDSAT-generated weights)

Variable	% (95% CI)	P
Age		
<25 years	10.1 (17.3–21.9)	<0.0001
≥25 years	19.6 (8.8–11.4)	
Sexual identity		
Gay	33.9 (30.2–37.7)	<0.0001
Bisexual	6.4 (5.3–7.4)	
Straight	10.1 (8.6–11.6)	
Monthly income		
≤R500	11.5 (10.4–12.6)	<0.0001
>R500	18.7 (15.4–22.1)	
Education		
Primary	15.8 (9.3–22.3)	0.48
Secondary	12.9 (11.7–14.3)	
Post-secondary	13.7 (11.3–16.2)	
Number of partners (6 mo)		
1	12.1 (9.7–14.5)	<0.0001
2	12.1 (10.2–14.1)	
3–5	11.4 (10.2–12.6)	
6–9	24.2 (18.8–29.5)	
10+	14.5 (9.0–20.0)	
Regular female partner		
Yes	5.8 (4.9–6.5)	<0.0001
No	24.4 (21.9–26.9)	
Regular male partner		
Yes	14.9 (13.5–16.2)	<0.0001
No	9.2 (7.2–11.3)	
Problem drinking (AUDIT > 9)		
Yes	12.8 (11.6–14.1)	0.14
No	14.1 (11.6–16.7)	
Marijuana use (6 mo.)		
Yes	10.5 (8.9–12.0)	<0.0001
No	14.1 (12.6–15.5)	
Bought drugs or alcohol for male partner		
Yes	25.7 (22.5–28.9)	<0.0001
No	10.4 (9.3–11.6)	
STI symptoms (12 mo.)		
Yes	14.3 (11.9–16.5)	0.08
No	12.7 (11.4–14.1)	
Circumcised		
Yes	5.8 (4.8–6.8)	<0.0001
No	17.3 (15.7–18.9)	
Prison (ever)		
Yes	13.1 (11.3–14.9)	0.93
No	13.2 (11.8–14.5)	
Receptive anal intercourse (ever)		
Yes	31.3 (28.4–34.3)	<0.0001
No	5.5 (4.7–6.2)	

Table 3 continued

Variable	% (95% CI)	P
Unprotected insertive anal (last 5 partners)		
Yes	15.2 (12.9–17.8)	0.001
No	12.4 (11.0–13.7)	
Unprotected receptive anal (last 5 partners)		
Yes	34.9 (29.9–39.8)	<0.0001
No	10.9 (9.8–12.0)	
Unprotected vaginal (last 5 partners)		
Yes	5.4 (4.6–6.3)	<0.0001
No	18.9 (17.1–20.8)	

Table 4 Multivariable logistic regression for HIV infection (using RDSAT-generated weights)

Variables	AOR[a] (95% CI)	P value
Age ≥25	3.8 (3.2–4.6)	<0.001
Sexual ID		
Bisexual	1	–
Straight	1.6 (1.2–2.0)	<0.001
Gay	2.3 (1.8–3.0)	<0.001
Monthly income <500	1.4 (1.2–1.7)	<0.001
Number of partners (6 mo)		
1	1	–
2	2.8 (2.1–3.8)	<0.001
3–5	1.9 (1.4–2.6)	<0.001
6–9	5.7 (4.0–8.2)	<0.001
10+	2.2 (1.5–3.3)	<0.001
Prison (ever)	1.1 (0.8–1.4)	0.487
Regular female partner	0.2 (0.2–0.3)	<0.001
Regular male partner	1.2 (1.0–1.5)	0.045
Marijuana use (6 mo)	0.6 (0.5–0.8)	<0.001
Bought drugs or alcohol for male partner	3.9 (3.2–4.7)	<0.001
Circumcised	0.2 (0.1–0.2)	<0.001
Unprotected receptive anal (last 5 partners)	4.4 (3.5–5.7)	<0.001
Unprotected insertive anal (last 5 partners)	1.1 (0.9–1.3)	0.385
Unprotected vaginal (last 5 partners)	0.5 (0.4–0.6)	<0.001
STI symptoms (12 mo)	0.7 (0.5–0.8)	<0.001

[a] Adjusted for all other variables in the model

Circumcision was associated with lower HIV prevalence. Given that most MSM in our sample reported practicing IAI exclusively, we conclude that there may be a protective association for MSM in South Africa for men who are consistently the insertive partners in anal sex with men. Although a meta-analysis of observational studies of circumcision in MSM populations by Millet et al. could not detect a consistent protective effect, the authors did find a

non-significant reduction in odds in settings with less than 50% circumcision prevalence, and concluded that more data on MSM who engage primarily in IAI would be helpful [24]. Given the potential for circumcision to decrease HIV transmission at the population level, and that many MSM who are insertive partners with men also have sex with women, this association should continue to be explored in further observational research with MSM throughout the region.

Our study has several limitations. RDS studies of MSM have been critiqued for overstating claims to unbiased population estimates because the samples actually recruited may not fully represent the underlying population, even after adjustment [25]. Although we attempted systematically to select seeds that would produce a well-networked and diverse sample, it is possible that men who are unemployed and who have lower socioeconomic status (SES) and educational achievement are not well networked with better educated and resourced MSM. Thus unemployed men of lower SES may be overrepresented in our sample. However, our results are likely representative of the most socially vulnerable MSM whose limited income, mobility, and economic opportunity may also limit their access to HIV prevention information, condoms and latex-compatible lubricant, and high-quality health services. It is notable that although black race and Soweto residence were not explicit inclusion criteria, the chains did not leave Soweto except in the case of one Coloured participant, suggesting that the legacy of apartheid continues to limit Soweto MSM's geographic and social mobility. It is also possible that the offer of VCT may have operated both as an additional recruitment incentive [26, 27] as well as a disincentive to participating altogether, biasing the results in ways that would be difficult to account for. The interviewer-administered questionnaires may have introduced social desirability bias with respect to self-report of sensitive sexual behaviors, including drug use, receptive AI, and/or unprotected AI. In addition, the multiple imputation procedure we followed for missing HIV results is untested, and to the extent that risk behavior may have been underreported, our imputation method would bias our prevalence estimate towards the extreme possibility of non-testers being HIV-negative. We acknowledge that our adjusted results are likely a conservative estimate of HIV prevalence in the target population.

Finally, our experience with the Soweto Men's Study shows that it is possible to engage MSM in HIV research in the absence of a functioning LGBT organization. It is always preferable to collaborate with and strengthen the capacity of LGBT organizations for MSM HIV research where possible, but the disadvantageous legal and social environment in much of sub-Saharan Africa may inhibit their ability to launch or sustain research and intervention initiatives in their respective communities. Like other

MSM studies in the region, our findings show that it is critical to begin addressing the needs of MSM for HIV prevention and treatment, and that individual MSM, health care practitioners, and researchers can engage in effective collaborations to improve health outcomes in this highly vulnerable population.

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