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Incidence of HIV infection and Sexually Transmitted Infections and Related Risk Factors among Very Young Men Who Have Sex with Men

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Abstract

Introduction—The HIV epidemic continues to disproportionately affect men who have sex with men (MSM) in the US, with over a third of new infections in MSM occurring in younger men. Very few studies have reported on HIV and STI incidence and related risks among younger MSM, particularly among minors under 18 years of age.

Methods—Data analyzed herein are from a longitudinal study of HIV-risk among 450 very young MSM in Chicago ages 16–20, recruited via respondent-driven sampling and followed for two years, with annual HIV and STI testing. We report estimated cumulative HIV and STI incidence over the 24-month follow-up using Kaplan-Meier methods and evaluated associations with incident infections using Cox Proportional Hazards regression.

Results—The final analytic sample was primarily non-White (83%); median age was 19; 25% of the sample was under age 18. 26 new HIV infections were detected over 632 person-years of follow-up. HIV incidence was 4.11/100 person years (95% CI=2.80–6.04) and STI incidence was 6.22/100 person-years (95% CI=4.54–8.51). Cumulative HIV incidence over 24 months of follow-up was 7.32% (95% CI= 5.05–10.57), with higher incidence among racial/ethnic minorities. In multivariate analyses, non-White race and recent sexual partner concurrency were associated with both HIV and STI infection; HIV testing history and sex with an HIV-positive partner were associated with increased risk of HIV infection.

Discussion—High rates of incident HIV infection and STIs among very young MSM and the relationship between incidence and race/ethnicity, concurrency and partner characteristics indicate potential focal points of future intervention and the need for continued vigilance.

Keywords

HIV/STI Infection; HIV/STI Epidemiology; Young Men Who Have Sex with Men

INTRODUCTION

In its fourth decade, the HIV epidemic continues to disproportionately affect gay, bisexual and other men who have sex with men (collectively referred to as MSM) in the United States.¹ Male-to-male sexual contact accounted for 65% of the approximately 47,000 new HIV infections during 2013,¹ even though MSM only represent 2% of the population.² Over 30% of new infections among MSM occur in young MSM (YMSM) aged 13–24,³ and young Black MSM accounted for more new infections than any other age group or race of MSM.³ Despite a recent increase in attention focused on prevention among YMSM,⁴ they continue to be vulnerable to becoming infected with HIV.⁵

Assessing HIV incidence allows researchers and practitioners to better understand the current and on-going epidemic in specific populations. Stall and colleagues conducted a meta-analysis of published incidence rates among MSM and found stable annual HIV incidence (2.39%) between 1995 and 2005,⁶ the first decade after the introduction of highly active antiretroviral treatment (HAART). Alarming, the researchers reported that if such incidence was sustained, cumulative prevalence of infection by age 40 would be 40%.⁶ Using a CDC estimate of 4.0% annual HIV incidence among Black YMSM,⁷ Stall et al estimated cumulative prevalence of 59.3% by age 40.⁶

More recent HIV incidence studies point to a troubling story for Black YMSM in the U.S. Data published from the 2008 cycle of the National HIV Behavioral Surveillance System (NHBS) estimated an annual HIV incidence rate of 2.9% for all YMSM aged 18–24; however, the annual rate for Black YMSM in the study was 5.1%.⁸ Koblin and colleagues reported similar findings from HIV Prevention Trials Network (HPTN) Study 061 (i.e., the BROTHERS Study) which enrolled a longitudinal cohort of Black MSM in six US cities. They found an annual HIV incidence of 3.0% for all Black MSM in the cohort, but an incidence of 5.9% for Black MSM under the age of 30.⁹ Sullivan and colleagues estimated 10.9 new HIV infections per 100 person years among Black MSM aged 18–24 enrolled in an Atlanta cohort study.¹⁰ Finally, in a recent study of YMSM, ages 18–19, in New York City (N=594), annual HIV incidence was 2.85 per 100 person years with a 3-year cumulative rate of 7.2% over the entire period.¹¹ An important limitation of these studies and the HIV incidence literature more generally, is that no MSM participants were under the age of 18 at the time of enrollment.

Factors associated with HIV incidence among YMSM in the studies cited above include Black or other race (vs. White),^{8,11} lower level of education (< high school), substance use before or during last sexual episode⁸ and having sex with an HIV-positive or unknown status partner.⁹ Koblin and colleagues found that among Black MSM in particular, younger men

had higher levels of sexual risk (i.e., more likely to report sex with HIV-positive/unknown status partners vs. older men), were more likely to have a sexually transmitted infection (STI) at follow-up, and were less likely to have a usual place for healthcare or to have visited a health care provider recently,⁹ thus providing evidence for risk behavior, concomitant STIs, and health care factors as potential reasons for high incidence among younger Black MSM (vs. older). A recent analysis of data from three longitudinal studies of MSM early in the highly active antiretroviral therapy era adds to this evidence finding higher per contact risk of HIV seroconversion (i.e., per sexual act) with HIV seropositive partners in younger MSM (<25 years of age), despite lower mean number of reported contacts, suggesting particular vulnerability associated with sexual risk and/or partner characteristics as explanatory factors in age disparities in HIV incidence across race/ethnicity.¹² Rationale for the underlying disparities in HIV incidence within YMSM by race/ethnicity have not been well-described, although evidence suggests that frequency/quantity of risk behavior, including substance use and condomless anal sex do not adequately explain disparities.¹³ Previous reviews of evidence to explain disparities by race/ethnicity among all MSM suggests that treatment factors such as high STI prevalence and undetected/late HIV diagnosis may partially explain disparate rates of HIV infection among Black MSM, however, no evidence suggests disparities are attributable to quantity/frequency of sexual risk behavior or substance use.^{14–16} Instead, evidence suggests they are better explained by network and structural factors.¹⁷ For example, Sullivan and colleagues found in their cohort of MSM in Atlanta that insurance status and partner race accounted for the racial disparity observed in their cohort.¹⁰

Co-morbid infection with bacterial STIs increases the risk of transmission and acquisition of HIV,^{18,19} and recent simulation studies suggest they play an important role in HIV infections among young MSM.²⁰ In a recent longitudinal cohort study of STI incidence in adult MSM in Atlanta, Kelley and colleagues found an annual rate of urogenital gonorrhea and chlamydia infection of 2.2 (95% CI: 0.9, 4.3) and 4.7 (95% CI: 2.7, 7.5) per 100 person years respectively, but much higher rates of rectal STIs and syphilis, (>6.1 per 100 person years) for Black men in particular.²¹ Unfortunately, we were unable to find any studies that specifically estimated STI incidence among YMSM using longitudinal study designs, thus there is a need to estimate both STI and HIV incidence in concert and the predictive potential of STIs on subsequent HIV incidence.

The purpose of this analysis is to fill gaps in the existing literature by calculating incidence of new HIV and urogenital gonorrhea/Chlamydia infections in very young MSM age 16–20 at baseline and to describe factors associated with new infections.

METHODS

Participant Recruitment

Data analyzed herein come from a longitudinal study of HIV-risk among 450 YMSM conducted between 2009 and 2015 in Chicago (known as “Crew 450”), the nation’s third largest city and the epicenter of the HIV/AIDS epidemic in the Midwest. The purpose of the study was to characterize the course, and predictors of HIV/STI risk and incident infection among YMSM. We used a modified form of respondent-driven sampling (RDS) to recruit

YMSM between ages 16 and 20, which yielded a greater proportion of initial recruits or “seeds” than a conventional RDS approach.²² Segmentation in patterns of recruitment by race/ethnicity and a relatively large number of Black seeds also resulted in overrepresentation of youth of color in the sample.²² Seeds were recruited through community-based convenience sampling with study promotional materials distributed via active and passive means in community locations frequented by YMSM. Eligible participants were within the target age-range at baseline, English-speaking, assigned a male sex at birth, had any prior sexual encounter with a male or identified as gay/bisexual, resided in Chicago or suburban Cook County, and were available for multiple follow-ups across 24 months. A total of four study enrollment sites in Chicago were utilized, three sites on the north side of the city and one on the near southwest side.

Data Collection and Measures

Following written assent/consent procedures, data were collected via computer-assisted self-interviewing (CASI) and participants were tested for HIV/STIs; follow-up interview data were collected approximately every 6 months thereafter, with HIV/STI testing completed at 12-month intervals. In order to retain participants over time, multiple attempts to contact them using all available contact information were made, including contacting friends, relatives, or others (whom the participants had indicated would always know how to contact them). Contact information was also updated at all study visits. Commercially available locator services were used to identify new contact information for those for whom all contact information became invalid, however, because of their young age (e.g., not often traceable via utility, mortgage or other billing), these services were not effective. Participants were reimbursed \$45 for their time and travel at each visit (except the baseline visit, which was divided into two visits, total compensation was \$70 at baseline), and the study received approval from institutional review boards of affiliated institutions, with waiver of parental permission for the participation of minors.

In terms of demographic indicators, participant age, race/ethnicity, and highest level of education were captured at the baseline interview as was self-reported HIV testing history (ever tested). Predictor variables were selected from a review of HIV among YMSM.⁵ Recall of prior six-month substance use and sexual risk were collected at baseline as well as all follow-up points and included: alcohol use, marijuana use, other drug use (i.e., cocaine, heroin, methamphetamines, opiates; non-prescription depressants, stimulants; psychedelics, Ecstasy, gamma hydroxybutyrate –GHB, Ketamine, and any inhalants), alcohol use during sex, drug use during sex, total male partners, unprotected anal sex with a male partner, sex with an HIV positive partner, sex with an unknown status partner, having exchanged sex for money or shelter, having concurrent sexual partners (i.e., either the participant or their most recent sexual partners), victimization by a sex partner (i.e., any affirmative response for any sex partner to the question: “Has [partner] ever hit, slapped, punched or hurt you?”), and having a male partner 5 years older. We included these last two variables in particular because of the young age of participants and prior work suggesting that developmental vulnerabilities, such as the assumed authority of older partners may put them at risk.²³ HIV infection was determined by oral OraQuick/Orasure™ testing for those with unknown status and by self-report for those with known status (self-reported HIV-positive status was

confirmed for 71% of self-reported cases via Orasure™, medical records or HIV-related medication prescription verification). Urogenital gonorrhea and Chlamydia infections were determined via urine polymerase chain reaction (PCR; Roche Diagnostics).

Statistical Analysis

Urogenital gonorrhea and Chlamydia infection were combined and analyzed as a single composite outcome (herein referred to as STI) to improve power and because risk factors for the acquisition of urogenital gonorrhea and Chlamydia are similar. Results and conclusions did not change when the two infections were examined individually (data not shown).

Analyses were conducted separately for HIV and STI to identify similarities or dissimilarities between exposures and associated risk of each infection. For STI, person-time was calculated as the time in months from the baseline visit (or the last visit at which the patient tested negative) to the first positive test. Participants with multiple infections were censored at the time of first infection. Loss to follow-up was defined as a case missing at a given time point not due to withdrawal, with no data provided at subsequent study visits. If participants missed a study visit and provided data at subsequent time points, all available data was included in the analysis. Participants who were lost to follow-up were censored at the last time point at which they provided data.

For HIV, person-time was calculated as the time from baseline to the last visit at which the patient tested negative or the midpoint of the interval between the first positive test and the preceding negative test for those who tested positive.²⁴ We also calculated person-time using the date of the first positive test rather than the midpoint as the time of HIV infection and results were not substantially changed; presented findings use the midpoint as the time of infection. Cumulative HIV incidence was estimated using the Kaplan-Meier method. Incidence rates of HIV and STI were compared across exposure categories using the log-rank test.

To assess the effect of fixed and time-varying exposures on HIV and STI, we fit extended Cox regression models with fixed and time-varying covariates to estimate univariable and multivariable hazard ratios for associations of exposures with incident infections. Age at baseline, race/ethnicity, education, ever having been tested for HIV, and infection with gonorrhea or Chlamydia at baseline were treated as time-fixed covariates for analysis. All other variables, including sexual behaviors and substance use, were assessed as time-varying. The timeframe for all exposures was the previous 6 months. The reported exposure at the time of infection was the exposure status associated with infection. For time-varying exposures, participants could contribute to exposed and unexposed risk sets at different time points. Variables with $p < 0.2$ in exploratory analysis were entered in multivariable models, and stepwise methods were used to select variables for the final models with $p < 0.10$ as the cutoff for retention in the final models. This cutoff was used instead of $p < 0.05$ due to relatively small sample size and small numbers of events across exposure categories. We assessed the proportional hazards assumption for the Cox models by graphical examination of log-log survival curves and by statistical testing for non-zero slope of the scaled Schoenfeld residuals on functions of time. The Efron method was used to approximate the exact conditional probability of tied failures.²⁵ Standard errors were adjusted for clustering

within recruitment chains. Data were analyzed using STATA 13.1 (StataCorp, College Station, TX).

RESULTS

Of 450 participants at baseline, 415 were HIV negative and included in this analysis. We excluded 34 (7.6%) participants who were previously HIV positive or tested HIV positive at baseline (n=21 previously positive, n=13 previously undiagnosed) and 1 participant for whom HIV status was unknown at baseline. Compared to participants who were lost to follow-up (n=60), participants retained (n=355) were less likely to report sex with a partner of unknown HIV status, substance use during sex, and exchange sex at the baseline visit and more likely to have completed post-secondary education, identify as gay, be a recruitment seed, and have a partner 5 years older ($p<0.05$ for all comparisons). No other differences in socio-demographics or baseline risk behaviors were identified. The final analytic sample consisted of 355/415 (86%) participants with at least one subsequent HIV test (328 were retained at 12 months and 297 were retained at 24 months); of these, 17% were White, 44% were Black, 33% were Hispanic, and 6% identified as other race/ethnicity. A total of 71% reported having at least one HIV test prior to baseline. The median age at study entry was 19 (range 16–20). Twenty-seven (7.8%) were infected with gonorrhea or Chlamydia at the baseline visit. Prevalence of risk behavior was high; in the 6 months prior to baseline, 65% had 2 male sex partners, 64% reported that they or their partner had concurrent partners, 49% reported unprotected anal intercourse (UAI), and 40% reported sex with a male partner of unknown HIV status. Use of alcohol and illicit substances during sex were reported by 38% and 25%, respectively (Table 1).

HIV Incidence

A total of 26 new HIV infections were detected over 632 person-years of follow-up; HIV incidence was 4.11 per 100 person years (95% CI=2.80–6.04). Cumulative incidence over 24 months of follow-up was 7.32% (95% CI= 5.05–10.57) overall, but varied significantly by race/ethnicity. The 24-month cumulative incidence was 1.67% (95% CI 0.24–11.25) among White MSM, 5.17% (95% CI= 2.36–11.15) among Hispanic MSM and 10.83% (95% CI= 6.87–16.84) among Black MSM (Figure 1). In univariable analysis, history of HIV testing, sex with an HIV positive partner, recent transactional sex, and recent concurrency were associated with increased risk of HIV infection; race/ethnicity and sex with a male partner 5 years older were associated with HIV incidence but the associations were marginally significant. There were no significant associations found with HIV incidence and age, level of education, baseline STI infection, substance use, sex under the influence of alcohol or drugs, number of partners, sex with unknown serostatus partners, or partner-related victimization. In multivariable Cox regression, non-White race (Black: aHR 8.81; 95% CI= 1.58–49.2; Other race: aHR 9.57; 95% CI=1.32–69.3), history of HIV testing at baseline (aHR 3.19; 95% CI=1.07–9.52), sex with an HIV positive partner (aHR 5.48; 95% CI=1.56–19.2) and recent concurrency (aHR 2.59; 95% CI=1.07–6.24) were associated with a statistically significantly increased risk of incident HIV infection (Table 2). UAI with a male partner, exchange sex, and sex with a partner 5 years older were not significantly associated with HIV infection in multivariable analysis.

STI Incidence

Over the follow-up period, incidence of first STI was 6.22 per 100 person-years (95% CI=4.54–8.51). In univariable analysis, recent concurrency was significantly associated with incident STI during follow-up; non-White race and baseline infection with gonorrhea or Chlamydia were associated with marginally increased risk of STI ($p<0.10$). No association was found with age, level of education, HIV testing history, substance use, sex under the influence, number of partners, unprotected anal sex, sex with HIV or unknown status partners, partner-related victimization or older partners. In multivariable analysis, non-White race (Black: aHR 9.22; 95% CI = 1.23–69.2; Hispanic: aHR 9.02; 95% CI 1.24–65.7; Other race: aHR 9.71; 95% CI 1.82–51.7) was associated with a significant increased risk of STI; recent concurrency (aHR 2.08; 95% CI= 0.96–4.48), was associated with increased risk of STI though the association was marginally significant ($p<0.10$) (Table 2).

DISCUSSION

Although YMSM are a well-known high-risk group, to our knowledge this is the first study documenting actual incidence and prevalence of HIV and urogenital sexually transmitted infections in very young MSM, including those under age 18. Prior published work on the incidence of HIV in YMSM and adult MSM such as the work emanating from the National HIV Behavioral Surveillance System has relied on estimates of incidence among MSM 18 years of age and above.⁸ The annual and cumulative incidence rates of HIV reported here for YMSM are comparable to published rates for largely older age groups (i.e., 18–29).^{8,11,26} To our knowledge, this is the first published study of STI incidence among YMSM and findings indicate annual rates of urogenital STIs as high or higher than the published data for adults MSM.²¹ Notably, the annual incidence of both HIV and STIs for minors aged 16–17 are not significantly different from those aged 18–20, suggesting the need for initiating intervention efforts among very young MSM. The incidence of HIV and STI infections in Black YMSM found in this study are particularly and strikingly high but to a large extent consistent with the current and evolving epidemiology of HIV in many urban centers of the U.S.

These data have important public health implications for the development of future HIV prevention interventions and specifically for the targeting of future interventions to younger MSM. Three decades into the U.S. HIV epidemic there is not a single intervention in the Centers for Disease Control and Prevention Compendium of Evidence-based HIV Behavioral Interventions (EBIs) supporting implementation in YMSM below age 18 years of age.²⁷ Although there are some promising interventions for YMSM currently in the development pipeline,^{28,29} the lack of proven interventions designed to meet their needs contrasts sharply with the incidence rates documented herein and evidence of disproportionate number of new HIV infections in this population.^{3,30} These high rates of incident HIV and urogenital STIs among YMSM in this study should be a wake-up call for health care providers working with these young men. Given the high risk for both HIV and STIs among younger (aged 16–17) as well as older members of the cohort (aged 18–20), health care providers and clinicians working with YMSM, need to prioritize health education and discussions of sexual risk and partner selection, including strategies for prevention and offer routine testing at regular intervals, consistent with current CDC

guidelines.³¹ For providers not specifically focusing on YMSM in their clinical practice, suggestions for dialogue with adolescent patients about sexual health and sexual orientation by the American Academy of Pediatrics are particularly important.³² Sexual minority adolescents experience stigma, discrimination and ostracism in society at large and within healthcare systems. Evidence suggests that among sexual minority youth who access primary care, a minority discuss sexual orientation with providers;³² this dialogue is even more important given the rates of HIV and STI incidence among YMSM reported herein.

Consistent with prior literature,⁵ reported rates of risky sexual behaviors were high across all racial and ethnic groups in our sample. While we did not find that substance use was related to HIV or STI incidence, these null findings may be due to relatively small sample size, the relatively young age of our participants at baseline (e.g. median age 19), and/or underreporting of substance use. In the Atlanta MSM cohort described above, in a comparison of self-reported substance use versus urine-based screening, Black MSM were more likely to under-report marijuana and cocaine use in comparison to White participants.³³ Underreporting of substance use could result in failure to detect associations with HIV incidence. In addition, in our sample, there was no statistically significant association between urogenital STI acquisition and incident HIV infections. The null findings may well be related to the young developmental age of the current study participants, the lack of screening for rectal STIs and syphilis in the current study, and/or sample size. In particular, because most HIV exposure in this population occurs via the rectal mucosa and rectal STIs were not subject to screening in this study, a significant association between STI acquisition and HIV incidence was less likely. Recent literature on substance use and sexual risk among both YMSM^{34–36} and adult MSM³⁷ suggest that it may be important to examine whether the relationships between substance use, risky sex and incident HIV infections or STIs evolve or establish themselves over time.

To date, very limited longitudinal research or natural history studies have been conducted among YMSM, particularly YMSM under the age of 18, a weakness in the existing HIV prevention literature identified in the 2011 Institute of Medicine (IOM) Report,³⁸ which highlights the needs of sexual minority youth as a research “priority area.” Our findings call for a broader exploration of the factors that might underlie risk and predict incident infections in these very young MSM. Our findings are consistent with published research^{11,12} suggesting that YMSM may be particularly vulnerable to the risk associated with partner selection and partner characteristics given the associations found herein between concurrent partners, HIV infected partners, and incident infections.

Our findings however should be carefully considered within the context of several limitations. First, the majority of HIV-related studies examining incidence and prevalence are either multi-site or reflect more nationally representative samples. In comparison, this study has a relatively small sample size and number of incident infections; limiting power for the examination of factors (e.g. substance use, sexual risk, or other) that may be associated with the acquisition of HIV or urogenital STIs in these young men. Furthermore, there was a fair amount of loss to follow-up in this study. Although this is expected in a longitudinal study, it can introduce selection bias if people who drop out of the study are different than those who stay in. In our study, those who dropped out of the study reported

higher levels of some potential risk factors (e.g., substance use in the context of sex, exchange sex), and thus our estimates of incidence and related factors may be conservative. As well, the use of OraQuick for HIV screening may have resulted in an underestimate of incidence given reduced sensitivity in the detection of early HIV infection.³⁹ Second, these young men are from one urban geographic area and our findings may not generalize to a larger, more diverse sample of YMSM. The over-representation of urban Black YMSM within our sample, that to a large extent drove the high incidence rates we report herein, may not reflect incidence rates of other non-urban or other more ethnically diverse populations of YMSM. Third, no data were collected on STIs from other anatomic locations (e.g. pharyngeal, rectal) nor was incidence of syphilis observed as part of this study although recent literature suggests higher rates of rectal chlamydia and gonorrhea infection among YMSM in comparison to urogenital infection⁴⁰ and a link between syphilis as well as rectal STIs with incident HIV infection.^{21,41,42} Fourth, while our annual STI screening protocol was consistent with CDC recommendations for sexually active MSM at the start of the study,⁴³ a full year between STI screenings may miss some incident infections, which may resolve spontaneously, particularly for chlamydia.⁴⁴ Despite these limitations this study is among the first to document strikingly high incidence rates of HIV among a very young sample of YMSM age 16–20 and to examine factors associated with the acquisition of both HIV and urogenital STIs among these young men.

During the course of study implementation, the US Food and Drug Administration (FDA) approved pre-exposure prophylaxis (PrEP) for the prevention of HIV infection⁴⁵ and the Centers for Disease Control and Prevention (CDC) issued clinical guidelines for its use among MSM.⁴⁶ Despite the availability of PrEP for HIV prevention, recent studies suggest uptake is low among the most at-risk populations.^{47,48} These findings, in combination with evidence from our study regarding high incidence among 16–17 year old ethnic minority YMSM suggest that current racial disparities in HIV incidence may increase of the short term. Making efficacious bio-behavioral interventions available to those most at-risk for HIV infection will be an important strategy to address the epidemic.

In conclusion, we hope this study will be the first of a growing and evolving body of longitudinal research examining a broad range of potential factors that may contribute to the acquisition of HIV and STIs in YMSM. To date, this population, particularly YMSM under age 18, have been understudied in both existing HIV intervention and epidemiological work. Our findings strongly suggest the need for more data in this area as we aim to reverse the current trend toward rising rates of HIV in YMSM, and specifically YMSM of color.

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Figure 1.

Table 1

HIV and STI Incidence by Sociodemographics and Risk Behaviors

	HIV				STI		
	Total ^a , N (%)	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c
Overall	355 (100.0)	26/632.0	4.11 (2.80–6.04)	--	39/627.5	6.22 (4.54–8.51)	--
Gonorrhea					16/636.0	2.52 (1.54–4.11)	--
Chlamydia					26/638.5	4.07 (2.77–5.98)	--
Age at baseline				0.463			0.309
16–17	89 (25.1)	8/155.0	5.16 (2.58–10.3)		12/151.0	7.95 (4.51–14.0)	
18–20	266 (74.9)	18/477.0	3.77 (2.38–5.99)		27/476.5	4.76 (3.89–8.26)	
Race/Ethnicity				0.091			0.093
White	60 (17.0)	1/111.5	0.90 (0.13–6.37)		1/109.0	0.92 (0.13–6.51)	
Black	157 (44.4)	17/275.0	6.18 (3.84–9.94)		20/278.0	7.19 (4.64–11.2)	
Hispanic	116 (32.8)	6/205.5	2.92 (1.31–6.50)		15/201.5	7.44 (4.49–12.3)	
Other	21 (5.9)	2/38.0	5.26 (1.32–21.0)		3/37.0	8.11 (2.62–25.1)	
Highest level of education				0.226			0.923
<HS	132 (37.2)	9/238.0	3.78 (1.97–7.28)		14/231.0	6.06 (3.59–10.2)	
HS diploma or GED	89 (25.1)	10/153.5	6.51 (3.51–12.1)		11/160.5	6.85 (3.80–12.4)	
College or trade school	134 (37.8)	7/240.5	2.91 (1.39–6.11)		14/236.0	5.93 (3.51–10.0)	
Ever tested for HIV				0.044			0.299
Yes	253 (71.3)	23/444.5	5.17 (3.44–7.79)		25/448.0	5.58 (3.77–8.26)	
No	102 (28.7)	3/187.5	1.60 (0.52–4.96)		14/179.5	7.80 (4.62–13.2)	
Gonorrhea or Chlamydia infection at baseline				0.423			0.056
Yes	28 (7.9)	1/52.0	1.92 (0.27–13.7)		6/47.5	12.6 (5.67–28.1)	
No	327 (92.1)	25/580.0	4.31 (2.92–6.38)		33/580.0	5.69 (4.04–8.00)	
Alcohol use^b				0.396			0.484

	STI				HIV			
	Total ^a , N (%)	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c	Incidence per 100 person-years (95% CI)
Yes	272 (76.6)	18/454.0	3.96 (2.50–6.29)		31/448.5	6.91 (4.86–9.83)		
No	83 (23.4)	8/144.5	5.54 (2.77–11.1)		8/148.0	5.41 (2.70–10.8)		
Marijuana use^b				0.947				0.997
Yes	193 (54.4)	14/325.0	4.31 (2.55–7.27)		21/320.5	6.55 (4.27–10.0)		
No	162 (45.6)	12/273.5	4.39 (2.49–7.73)		18/276.0	6.52 (4.11–10.4)		
Other drug use^b				0.660				0.306
Yes	52 (14.7)	5/103.0	4.85 (2.02–11.7)		4/102.0	3.92 (1.47–10.4)		
No	303 (85.4)	21/529.0	3.97 (2.59–6.09)		35/525.5	6.66 (4.78–9.28)		
Alcohol use during sex^b				0.267				0.291
Yes	136 (38.4)	7/231.0	3.03 (1.44–6.36)		12/223.5	5.37 (3.05–9.45)		
No	218 (61.6)	19/367.0	5.18 (3.30–8.17)		27/373.0	7.24 (4.96–10.6)		
Drug use during sex^b				0.684				0.738
Yes	88 (24.9)	5/142.5	3.51 (1.46–8.43)		10/137.5	7.27 (3.91–13.5)		
No	266 (75.1)	21/455.5	4.61 (3.01–7.07)		29/459.0	6.32 (4.39–9.09)		
Total male sex partners^b				0.572				0.214
0	49 (13.9)	4/115.0	3.48 (1.31–9.27)		5/118.5	4.22 (1.76–10.1)		
1	74 (21.0)	5/172.5	2.90 (1.21–6.96)		16/167.5	9.55 (5.85–15.6)		
2	230 (65.2)	17/311.0	5.47 (3.40–8.79)		18/310.5	5.80 (3.65–9.20)		
UAI with male partner^b				0.162				0.466
Yes	174 (49.3)	14/251.0	5.58 (3.30–9.42)		19/247.5	7.68 (4.90–12.0)		
No	179 (50.7)	12/347.5	3.45 (1.96–6.08)		20/349.0	5.63 (3.70–8.88)		
Sex with HIV positive partner^b				0.003				0.591
Yes	16 (4.5)	4/16.0	25.0 (9.38–66.6)		1/17.0	5.88 (0.83–41.8)		
No	338 (95.5)	22/582.0	3.78 (2.49–5.74)		38/579.5	6.56 (4.77–9.01)		

	HIV				STI			
	Total ^a , N (%)	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c	Infections/ person-years	Incidence per 100 person-years (95% CI)	p-value ^c	
Sex with unknown status partner^b								
Yes	142 (40.1)	6/183.5	3.27 (1.47–7.27)	0.454	12/180.5	6.65 (3.78–11.7)		0.905
No	212 (59.9)	20/414.5	4.83 (3.11–7.48)		27/416.0	6.49 (4.45–9.46)		
Exchange sex for money or shelter^b								
Yes	20 (6.3)	3/20.0	15.0 (4.84–46.5)	0.022	1/18.5	4.51 (0.76–38.4)		0.757
No	297 (93.7)	19/482.0	3.94 (2.51–6.18)		36/476.0	7.56 (5.46–10.5)		
Participant or partner had concurrent partners^b								
Yes	226 (64.0)	20/317.5	6.30 (4.06–9.76)	0.025	26/314.5	8.27 (5.63–12.1)		0.050
No	127 (36.0)	6/280.5	2.14 (0.96–4.76)		13/282.0	4.61 (2.68–7.94)		
Victimization by partner^b								
Yes	54 (15.3)	3/49.5	6.06 (1.95–18.8)	0.706	1/47.0	2.13 (0.30–15.1)		0.262
No	298 (84.7)	23/548.5	4.19 (2.79–6.31)		38/549.5	6.92 (5.03–9.50)		
Sex with partner 5 years older^b								
Yes	80 (23.9)	11/157.0	7.01 (3.88–12.7)	0.083	14/157.5	8.89 (5.26–15.0)		0.208
No	255 (76.1)	15/415.0	3.61 (2.18–6.00)		25/412.5	6.06 (4.10–8.97)		

CI indicates confidence interval

^aFrequencies are based on the distribution at baseline, including time varying covariates. Totals may not sum to 355 due to missing data.

^bTimeframe for exposure is the previous 6 months. For time varying exposures, participants could contribute person-time in exposed and unexposed states.

^cp-values estimated by log-rank test.

Of 450 participants, 415 were HIV negative at baseline and eligible for inclusion in the analysis. The analytic sample consisted of 355/415 (86%) men with at least 1 follow-up test. Of these, 328 had follow-up through 1 year and 297 had follow-up through 24 months.

Table 2

Results from Univariable and Multivariable Cox Regression with Time-Dependent Exposures: Factors Associated with Incident HIV and STI, N=355

	HIV				STI			
	Univariable HR ^a (95% CI)	p- value	Multivariable HR ^a (95% CI)	p- value	Univariable HR ^a (95% CI)	p- value	Multivariable HR ^a (95% CI)	p- value
Age in years at baseline	0.88 (0.65–1.18)	0.391	0.78 (0.59–1.05)	0.097	0.93 (0.75–1.16)	0.528	--	--
Race/Ethnicity								
White	1.0 (Ref)	--	1.0 (Ref)	--	1.0 (Ref)	--	1.0 (Ref)	--
Black	6.84 (0.92–50.7)	0.060	8.81 (1.58–49.2)	0.013	8.11 (0.88–50.6)	0.045	9.22 (1.23–69.2)	0.031
Hispanic	3.23 (0.41–25.6)	0.238	3.72 (0.59–23.6)	0.164	8.34 (1.01–53.8)	0.038	9.02 (1.24–65.7)	0.030
Other	5.87 (0.58–59.8)	0.135	9.57 (1.32–69.3)	0.025	9.16 (1.55–43.9)	0.010	9.71 (1.82–51.7)	0.008
Ever tested for HIV (baseline)	3.21 (1.01–10.2)	0.047	3.19 (1.07–9.52)	0.038	--	--	--	--
Sex with HIV positive partner	4.58 (1.52–13.8)	0.007	5.48 (1.56–19.2)	0.008	--	--	--	--
Participant or partner had concurrent partners	2.73 (1.19–6.24)	0.018	2.59 (1.07–6.24)	0.034	1.92 (0.87–4.26)	0.108	2.08 (0.96–4.48)	0.062
Any UAI, past 6 months	1.72 (0.81–3.65)	0.158	--	--	--	--	--	--
Exchange sex, past 6 months	3.68 (1.06–12.8)	0.041	--	--	--	--	--	--
GC or CT at baseline	--	--	--	--	2.29 (0.93–5.62)	0.072	--	--
Sex with partner 5 years older	1.97 (0.89–4.37)	0.095	--	--	--	--	--	--

HR indicates Hazard Ratio; CI indicates confidence interval

^aHazard ratios are estimated from Cox regression models with time varying exposures measured at 6, 12, 18, and 24 months post-baseline. Variance estimates account for clustering by recruitment chains. Multivariable HRs represent the effect of the exposure adjusted for other variables presented.