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Explaining Racial Disparities in HIV Incidence in a Prospective Cohort of Black and White Men Who Have Sex With Men in Atlanta, GA: A Prospective Observational Cohort Study

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Abstract

Purpose—To describe factors associated with racial disparities in HIV incidence among men who have sex with men (MSM) in the United States.

Methods—In a longitudinal cohort of black and white HIV-negative MSM in Atlanta, HIV incidence rates were compared by race. Incidence hazard ratios (HR) between black and white MSM were estimated with an age-scaled Cox proportional hazards model. A change-in-estimate approach was used to understand mediating time-independent and -dependent factors that accounted for the elevated HR.

Results—Thirty-two incident HIV infections occurred among 260 black and 302 white MSM during 823 person-years (PY) of followup. HIV incidence was higher among black MSM (6.5/100PY; 95% CI: 4.2, 9.7) than white MSM (1.7/100PY; CI: 0.7, 3.3), and highest among young (18–24 years) black MSM (10.9/100PY; CI: 6.2, 17.6). The unadjusted hazard of HIV infection for black MSM was 2.9 (CI: 1.3–6.4) times that of white MSM; adjustment for health insurance status and partner race explained effectively all of the racial disparity.

Conclusions—Relative to white MSM in Atlanta, black MSM, particularly young black MSM, experienced higher HIV incidence that was not attributable to individual risk behaviors. In a

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setting where partner pool risk is a driver of disparities, it is also important to maximize care and treatment for HIV-positive MSM.

Keywords

HIV incidence; racial disparities; cohort studies; men who have sex with men

Introduction

HIV epidemiology in the United States is driven by an unrelenting epidemic among men who have sex with men (MSM)(1, 2) and is remarkable for black/white disparities in HIV among MSM(3) and for expanding subepidemics among young black MSM. There is an emerging consensus that factors beyond individual risk behaviors (e.g., structural factors(4), access to healthcare(4), and features of sexual networks(5)) are key to understanding black/white disparities. HPTN-061 described HIV incidence among black MSM in 6 US cities and identified younger age and unprotected anal intercourse (UAI) as associated with incidence, but did not have a non-black comparison group, and therefore could not explore reasons for disparities.(6)

How we think about reasons for black/white disparities among US MSM was elegantly framed by Millet et al in 2006(7); this conceptual framework has guided the scientific agenda in the field for nearly a decade. We conducted a prospective, cohort study of black and white MSM in Atlanta that systematically measured the domains suggested by Millett to assess their potential to explain racial differences in HIV incidence. We recently reported on the baseline findings from this cohort study(3). Here, we present HIV incidence among HIV-negative men followed prospectively and explore which factors might account for observed black/white disparities in HIV incidence. In addition, we consider the implications of how non-behavioral factors associated with risk relate to eligibility criteria for pre-exposure prophylaxis (PrEP) and risk for new HIV infections.

Materials and Methods

Recruitment

InvolveMENT was a prospective cohort study designed to assess the multilevel factors associated with disparities in HIV incidence between black and white MSM in Atlanta. The study recruitment, baseline procedures, and baseline results are described elsewhere.(3) MSM were recruited from 2010 to 2012 via venue-time-space sampling and Facebook.(3, 8) Eligible MSM self-reported black or white race, non-Hispanic race/ethnicity, were male at birth, lived in the Atlanta Metropolitan Statistical Area, had 1 male sex partner in the previous 3 months and were not in a mutually monogamous relationship. Participants who had a non-reactive HIV test result at baseline were offered participation in prospective follow-up (Figure 1). This study was approved by the Emory University IRB (protocol 42405).

Prospective follow-up

Participants were followed for up to 24 months, with study visits at 3, 6, 12, 18, and 24 months after enrollment, until HIV seroconversion or censoring. At study visits, participants completed HIV/STI testing and counseling and behavioral assessment. Participant follow-up ended in March 2014. Some participants were administratively censored at 12 and 18 months of follow-up, due to funding reductions.

HIV/STI testing

At study visits, participants were screened for antibodies to HIV with a rapid HIV rapid test. (3) For men who had a preliminary positive result, additional specimens were collected for confirmatory testing using western immunoblot, CD4+ lymphocyte count and HIV-1 viral load testing. For one incident case, HIV infection was confirmed with two additional HIV rapid tests.(9, 10) All HIV-infected participants were linked to HIV care. For men who tested HIV-positive at their first (3-month) follow-up visit, HIV-1 RNA testing was performed on stored blood specimens from the baseline visit to document acute infection at enrollment. Participants were tested at each visit for syphilis, urethral gonorrhea (GC) and chlamydia (CT), and rectal gonorrhea and chlamydia as previously published.(3)

Longitudinal behavioral assessments

At baseline, participants completed a computer-assisted self-interview (CASI) questionnaire. Domains included demographics, residential address, individual-level HIV-related behaviors, health insurance coverage, and a dyadic inventory of the most recent 5 sex partners in the previous 6 months.(3) Prospective questionnaires reassessed socioeconomic status, residence, and aggregate sexual and substance use behaviors.

Measures

Explanatory variables—We considered several domains of possible explanatory factors: sociodemographic factors, biological factors increasing susceptibility, sexual network features, and neighborhood factors.

Demographic/social factors included age, sexual identity, educational attainment, poverty, employment, health insurance status, homelessness, and recent arrest. Circumcision status was assessed by self-report, as was use of illicit non-injection and injection drugs.(11) Sexual behaviors included reported partner number, reporting any main partners, any anal intercourse (AI) partners, and any unprotected anal intercourse (UAI) partners.(12) UAI was defined by reporting 1 UAI partners (including reporting failure or incomplete use of condoms) or by diagnosis of a new rectal STI. *Biological factors* included circumcision and STI diagnoses. *Sexual network features* hypothesized as causes of the disparity were having older partners, black-race partners, and partners of serodiscordant/unknown HIV status.(7) *Neighborhood factors* were operationalized as several census-tract factors (see Table 1). Methods for residence geocoding and census-tract data sources were previously described. (3) Data were primarily from the 2008–2012 American Community Survey.

In HIV incidence analyses, most factors were time-independent (sexual identity, education, health insurance, circumcision, and census-tract factors were assessed only at baseline).

Each reported value was assumed to apply since the last visit, including intervals containing missed visits. For missing values for time-dependent factors, we conservatively assumed non-occurrence of the factor, rather than carrying forward earlier values, which might impute risk where none actually occurred.

To understand how men in our cohort would have been evaluated for pre-exposure prophylaxis (PrEP) based on current eligibility guidelines(13), we analyzed self-reported behaviors in the 6 months before baseline visit. Based on these responses, we determined whether each of our seroconverting men would have met current CDC eligibility criteria for PrEP, overall and stratified by race.

Person-time for HIV incidence—For participants who remained HIV-negative throughout follow-up, person-time was the difference between the date of the final study visit and enrollment. For HIV seroconverters, the date of seroconversion was halfway between the date of new HIV diagnosis and the previous visit. Those with acute HIV infection (i.e., HIV antibody negative participants at baseline for whom HIV-RNA testing was conducted and results were RNA-positive) were considered as seroconverters and assigned an infection date of 12 days before enrollment.

Analysis

Statistical methods—For prospective participants, we descriptively summarized the above explanatory factors at baseline and compared black and white MSM using χ^2 , Fisher's exact, and Wilcoxon tests. We found minimal clustering of men in census tracts, and therefore treated census-tract factors as individual level exposures.(3) Cumulative study retention was estimated by the Kaplan-Meier method.

Cumulative HIV incidence was estimated by the Kaplan-Meier method, stratified by race, and by race and age at study enrollment, with differences in failure curves evaluated by the logrank test. For each racial group and explanatory variable, we computed bivariate incidence-density rates, rate-ratios (RR), and exact 95% confidence intervals, with participants able to contribute person-time to multiple categories for time-dependent variables.

We assessed which factors accounted for the elevated HIV infection hazard for black MSM by serving as mediators between participant race and HIV acquisition.(14) Using Cox proportional hazards models, we first estimated the unadjusted black/white hazard ratio (HR) for HIV incidence. Factors that diminished the adjusted HR for race by 10%, were considered meaningful mediators.(15) These mediators were then forward-entered to arrive at the multivariable set of mediators. For all models, race and potential mediators' adjusted HR with 95% CI were estimated. A forward-selection approach was chosen because of the limited number of seroconversion endpoints relative to the potential set of covariates for inclusion. Cox models used participant age, rather than study time, as the time scale to optimally account for the observational study design.(16) Analyses were conducted in SAS 9.3 (Cary, NC).

Results

Of the 803 black and white MSM who enrolled in the study, 237 had a reactive HIV rapid test at baseline (Figure 1). Of the remaining 566 MSM, 4 were administratively discontinued at the baseline visit: 562 MSM (260 black, 302 white) were followed prospectively for 853 person-years (PY), with 843 PY counting towards HIV incidence estimation and 79% cumulative retention, with no difference by race.⁽⁸⁾ Two participants were discontinued administratively during prospective followup (1 white and 1 black).

Baseline features

Baseline characteristics of the prospective sample are presented in Table 1. Relative to white MSM, black MSM were younger and less likely to identify as gay, have attained a college degree, and have health insurance. Black MSM were more likely to live in poverty, been recently homeless, and been recruited in venues. Examining sexual behaviors and partnership attributes, white MSM reported more male partners in the previous 12 months, but no racial differences were observed in reporting a main partner, engaging in anal intercourse or unprotected anal intercourse (UAI), or having older partners. Black MSM were more likely to report black partners and HIV serodiscordant/unknown UAI partners. Self-reported non-injection drug use was higher among white MSM. Black men were more likely than white men at baseline to have a rectal CT or GC infection or a urethral GC infection.

HIV incidence

During the two-year follow-up, 32 incident HIV infections were observed (rate: 3.8/100PY); cumulative HIV incidence was 11.1% for black and 3.5% for white MSM ($p < .0001$, Figure 2A.) and respective race-specific incidence density rates were 6.5/100PY vs. 1.7/100PY (RR: 3.8, Table 2).

Young black MSM (18–24 years) had the highest cumulative incidence at 16.4%, compared to other groups ($p < .00001$, Figure 2B). The incidence-density rate for black MSM 18–24 years was 10.9/100PY. Among other groups, the incidence density rate was 3.6/100PY for black MSM ≥ 25 years, was 0.9/100PY for white MSM 18–24, and 1.9/100PY for white MSM ≥ 25 years (Table 2).

Other significant sociodemographic predictors of HIV incidence in bivariate comparisons were lower education and lack of health insurance at baseline (Table 2). Sexual identity, current poverty, current unemployment and recent homelessness and arrest were not significantly associated with new HIV infections, although in some cases the associations were in the expected direction.

Sexual behaviors and partnership factors associated with HIV incidence were recent UAI, having black race partners, and having older partners. In addition to the factors reported in the table, the number of self-reported UAI partners was associated with incidence (HR= 1.37, 95% CI 1.03–1.82). Although incidence rates were qualitatively higher for men reporting main partners, anal intercourse, serodiscordant/unknown partners, and serodiscordant/unknown UAI partners, differences were not statistically significant. Neither

self-reported substance use nor circumcision was associated with HIV incidence. Among census-tract factors, only the percent of residents who are non-Hispanic black/African-American was significantly associated with HIV incidence.

Mediators of racially-disparate HIV incidence

In the unadjusted Cox proportional-hazards models of HIV incidence, the black/white incidence hazard ratio was 2.86 (95% CI: 1.3–6.4). In models adjusting for hypothesized mediators, no individual-level risk behaviors meaningfully reduced the aHR. The only individual-level factor that meaningfully reduced the race aHR was health insurance status (race aHR = 2.53, CI: 1.10–5.84; 10% decrease); at the dyadic level, reporting black-race partners reduced the race aHR (aHR = 1.65, CI: 0.65–4.19; 42% decrease). Controlling for both factors simultaneously, the race aHR was 1.56 (CI: 0.60, 4.05; 45% decrease). In both models that controlled for partner race, the effect of participant race was no longer significant ($p = 0.30$ and 0.36 , models with and without control for insurance, respectively). In separate models that considered neighborhood-level factors, median household income (race aHR = 2.42, CI: 1.03, 5.68; 16% decrease) and percent of residents who are non-Hispanic black/African-American (race aHR = 2.47, 95% CI: 1.03, 5.95; 14% decrease) mediated the race disparity. Controlling for both neighborhood factors simultaneously, the race aHR slightly decreased by 18.6% (aHR = 2.34, CI: 0.96, 5.69) and was no longer statistically significant ($p = 0.06$).

PrEP Eligibility

Of the 31 men who seroconverted and had behavioral data to assess PrEP eligibility, 22 (65%) met current PrEP eligibility guidelines at baseline assessment. By race, 15 of 23 (65%) black men and 7 of 8 (88%) white men who seroconverted met PrEP eligibility guidelines.

Discussion

In Atlanta, MSM and especially young black MSM face high-incidence epidemics of HIV. Overall incidence among MSM in Atlanta was 3.8% -- higher than estimated incidence for MSM in the United States overall (17). Over 1 in 10 young MSM Atlantans acquired HIV per year during our study period. We report a local depiction of the national trends towards a dramatic HIV epidemic among young black MSM (18). These data illustrate an ongoing, inadequately addressed public health emergency that demands urgent action in Atlanta and, likely, in other local epidemics in the Southeastern United States.

The InvolveMENt study was developed on a theoretical platform of ecological theory; we conceptualized possible exposures as individual behavioral/social, dyadic, and neighborhood levels.(3) We found, as others have (7, 19, 20), that individual-level risk behaviors such as UAI were associated with risk of HIV acquisition, but did not explain the disparities in HIV acquisition between black and white men. At the dyadic level, characteristics of the “partner pool” – i.e., the extent to which men reported partners from groups like older men and black men that likely have higher HIV prevalence(21) – were associated with HIV incidence. Having black partners did explain black/white disparities. It is critical not to stigmatize

groups of MSM among whom prevalence is higher. Thus, it would be erroneous to interpret our finding of the mediation of black/white disparities by black partners as suggesting that having black partners is a “risk” in the commonly understood sense of the word. Rather, our finding speaks to the importance of providing adequate HIV screening, and, for men found to be living with HIV, adequate and effective HIV treatment. This recommendation is especially important among black MSM, for whom access to health insurance and effective treatment is known to be more limited.(4, 22)

Given the substantial race mixing in our study(3), it is also critical to further understand race assortativity and heterogeneity in network prevalence of HIV. That is, what are the structures and mechanisms through which patterns of partnerships lead to higher risk for acquisition of HIV infection, despite comparable risk behaviors? Recent studies have documented the higher occurrence of race-concordant partnerships for black MSM(23) and relationships with sexual risk by race of partner.(24) There may also be differences in the accuracy of perceived HIV serostatus of partners by race.(25) Two census tract factors, median household income and proportion of black residents, also mediated disparities; these factors mirror, at the neighborhood level, the other important mediators (black sex partners and lack of health insurance).

Having health insurance at baseline was inversely associated with risk for HIV acquisition and explained black/white disparity. Having health insurance might directly influence risk in some ways, such as broader or faster access to STI screening and treatment. However, at least part of the observed mediation is likely because health insurance represents a range of social determinants of health, and is correlated with characteristics such as education, health literacy and poverty; lower education and poverty which influenced the aHR in the same direction as lack of health insurance (i.e., mitigated disparity), but not significantly.(26) Lack of health insurance may also represent lower access to HIV prevention services and lower access to treatment and viral suppression of one’s HIV-positive partners.(27) The Affordable Care Act offers opportunities to increase coverage of health care, either through qualified health insurance plans or through Medicaid expansion in some states. Increased access to health care offers multiple mechanisms to reduce differential risks for black MSM, including TasP, continuum-based interventions, and PrEP(28). These tools are urgently needed for black MSM.(29)

Although our mediation analyses demonstrated that the point estimate for disparity could be brought statistically to the null by accounting for having black partners, there is likely a portion of the disparity that remains unexplained. Further, the confidence intervals for race while controlling for health insurance and black-race partners are wide. It is important that we continue to explore how higher-order factors shape more proximal exposures. For example, there is evidence that patterns of race mixing within partnerships are driven in part by stigma: non-black men reported preferring non-black partners partly because perception of high HIV prevalence among black MSM.(23) Having black partners is merely the most proximal marker of behaviors that are likely shaped by racism, stigma, and racial segregation within urban settings. There were a number of other mediators, such as having a main partner, selected drug use variables, and neighborhood violent crime rates, which, if equalized between black and white participants, would result in increased disparity by race.

Further, it is important to explore possible biological explanations for disparate HIV susceptibility, and the common causes of the similar STI disparities.(30)

Some of Millet's original hypotheses were not supported by our data. For example, recent incarceration(31) had a strong but non-significant association with race, but failed to change the race HR. Similarly, having older sex partners was associated with HIV incidence but did not explain the observed racial disparities.

Overall, our findings are consistent with major themes from HPTN 061 ("Brothers") study(32), but provide further understanding and explanation of those findings. Our observed HIV incidence among black MSM at 6.6% is double the incidence in the HPTN 061 study (3.0%), and our observed incidence among young black MSM (11.6%) was nearly double that observed among the youngest age group in Brothers (5.9%).(6) The Atlanta-specific rate from Brothers (4.8%) was based on 8 infections and was the second highest of the six cities that participated in that study. However, HPTN did not have a white comparison cohort and our data provide an opportunity empirically test which exposures accounted for black/white disparities in HIV incidence.

Our study was subject to important limitations. The disparity by race was most extreme in young MSM, but we had insufficient power to examine this interaction and the possible factors accounting for the young MSM disparity. Similarly, we had insufficient incidence outcomes to extensively evaluate confounding of the disparity-mediating factors in more parameterized multivariable models. Our substance use variables were likely subject to misclassification: an analysis of the self-reported baseline measures indicated systematic underreporting of substance use by black participants.(11) Longitudinal studies with biological substance measures over time are needed. Other self-reported measures might have also been subject to differential misclassification.(33) We used systematic sampling methods, but our cohort was not representative of all black and white MSM in Atlanta. STIs were not considered as exposures in this analysis because of methodological complexities in appropriate assessing the relationships among STI, UAI, and HIV risk; we have separately used appropriate methods to resolve the independent association of incidence STIs with HIV incidence.(30)

Black MSM, and especially young black MSM, in Atlanta are at very high risk for HIV infection. According to our data, sexual network factors, social determinants, and neighborhood factors may supersede individual behaviors as drivers of HIV disparities. This finding has important implications for prevention. As illustrated in our data, because the increased risk for black MSM is not related to excess individual risk behaviors, current PrEP eligibility guidelines which are based on individual-level behaviors are likely to systematically underestimate the risk for black MSM, and thereby miss many PrEP candidates. More broadly, these data document an urgent need to provide the tools we have at hand – including PrEP and non-occupational post-exposure prophylaxis – and to continue research to understand the pathways through which higher-level factors act to increase the HIV acquisition risk of black men with comparable individual levels of behavioral risk to their white peers.

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Figure 1.
STROBE diagram for an HIV/STI incidence cohort of black and white non-Hispanic MSM followed in Atlanta, 2010–2014

*6 participants with acute infections at baseline continued to be followed prospectively

Figure 2.

Kaplan Meier plots illustrating incident HIV infection in 562 black and white non-Hispanic MSM followed in an HIV/STI incidence cohort, Atlanta, 2010–2014

Figure 3.

Adjusted black-white hazard ratios for HIV infection from multivariable models, in a cohort study of 562 black and white non-Hispanic MSM, in an HIV/STI incidence cohort, Atlanta, 2010–2014

- Adjusted HR for race not estimable due to lack of incident infections among those reporting injecting drug use
- Yellow region indicates covariate-adjusted HR for race that are between 0% and 10% less than the HR for race without covariate adjustment, whereas green region indicates covariate-

adjusted HR that are more than 10% less, indicating meaningful mediation of the race disparity in HIV incidence.

Baseline characteristics of 562 black and white MSM followed in an HIV/STI incidence cohort, Atlanta, 2010–2014

Table 1

	Overall (N=562)	Black (n=260)	White (n=302)	p-value
	% (N)	% (N)	% (N)	
Age, years	(N = 562)	(n = 260)	(n = 302)	< .0001
18 – 24	41.1 (231)	50.4 (131)	33.1 (100)	
25	58.9 (331)	49.6 (129)	66.9 (202)	
Sexual identity	(N = 562)	(n = 260)	(n = 302)	< .0001
Homosexual / gay	84.9 (477)	76.2 (198)	92.4 (279)	
Bisexual	12.3 (69)	20.0 (52)	5.6 (17)	
Heterosexual / straight, Other	2.3 (16)	3.8 (10)	2.0 (6)	
Education	(N = 561)	(n = 260)	(n = 301)	< .0001
College, post-graduate, or professional school	46.5 (261)	35.4 (92)	56.1 (169)	
Some college, associate's degree, technical school	36.5 (205)	40.4 (105)	33.2 (100)	
High school or GED, or less	16.9 (95)	24.2 (63)	10.7 (32)	
Poverty, current	19.7 (95/483)	28.8 (59/205)	13.0 (36/278)	< .0001
Employed, current	79.3 (445/561)	76.1 (297/259)	82.1 (248/302)	0.08
Health Insurance, current	66.1 (366/554)	53.9 (137/254)	76.3 (229/300)	< .0001
Homeless, previous 12 months	8.8 (511/560)	13.5 (35/260)	4.7 (14/300)	0.0002
Arrested, previous 12 months	10.1 (57/562)	11.9 (31/260)	8.6 (26/302)	0.19
HIV-testing history				
Lifetime	93.3 (523/561)	91.9 (238/259)	94.4 (285/302)	0.24
Previous 12 months	73.0 (409/560)	71.3 (184/258)	74.5 (225/302)	0.40
Recruitment site	(N = 562)	(n = 260)	(n = 302)	< .0001
Atlanta venue	85.6 (481)	91.9 (239)	80.1 (242)	
Facebook	14.4 (81)	8.1 (21)	19.9 (60)	
Sexual behaviors, previous 12 months				
Male sex partners median (Q1, Q3), n	6 ([4, 10], 558)	5 ([3, 9], 258)	7 ([4, 12], 300)	< .0001
Any main partner	47.6 (265/557)	43.2 (112/259)	51.3 (153/298)	0.06
Any AI	95.0 (534/562)	93.1 (242/260)	96.7 (292/302)	0.05

	Overall (N=562) % (N)	Black (n=260) % (N)	White (n=302) % (N)	p-value
Any UAI	80.3 (451/562)	78.5 (204/260)	81.8 (247/302)	0.32
<i>Drug use, previous 12 months</i>				
Any drug use^b	43.8 (245/560)	34.0 (88/259)	52.2 (157/301)	<.0001
Marijuana^b	40.3 (225/559)	33.2 (86/259)	46.3 (139/300)	0.002
Cocaine, crack-cocaine^b	16.9 (92/544)	6.8 (17/251)	25.6 (75/293)	<.0001
Methamphetamine^b	4.2 (23/545)	0.4 (1/251)	7.5 (22/294)	<.0001 ^a
Poppers	11.6 (63/544)	3.2 (8/250)	18.7 (55/294)	<.0001
Other non-injection (non-poppers)^c	21.2 (114/538)	10.2 (25/245)	30.4 (89/293)	<.0001
Injection	0.7 (4/561)	0.0 (0/260)	1.3 (4/301)	0.13 ^a
Circumcised	88.8 (467/526)	86.4 (209/242)	90.1 (258/284)	0.10
<i>Sexually transmitted infections, prevalent</i>				
Syphilis RPR positive	7.7 (43/560)	12.7 (33/259)	3.3 (10/301)	<.0001
Urethral Chlamydia	2.9 (16/561)	3.5 (9/259)	2.3 (7/302)	0.41
Rectal Chlamydia	9.1 (19/210)	13.7 (13/7)	3.2 (3/93)	0.009
Urethral Gonorrhea	1.1 (6/561)	2.3 (2/3)	0.0 (0/302)	0.009 ^a
Rectal Gonorrhea	5.2 (11/210)	8.6 (10/117)	1.1 (1/93)	0.02 ^a
Serodiscordant/unk. HIV status UAI partners	26.1 (144/551)	33.1 (84/254)	20.2 (60/297)	0.0006
Partner 10 years older	28.7 (159/554)	30.8 (78/253)	26.9 (81/301)	0.31
Black race partner	50.5 (283/560)	87.2 (225/258)	19.2 (58/302)	<.0001
Sexual Network				
Percent living in poverty	mean (std. dev, median) 20.2 (12.5, 17.3)	mean (std. dev, median) 23.3 (12.5, 22.4)	mean (std. dev, median) 17.6 (11.8, 14.9)	<.0001
Median annual household income	\$53,135 (\$23,327, \$51,793)	\$45,004 (\$20,134, \$41,054)	\$60,082 (\$23,650, \$56,693)	<.0001
Percent of adults with high school degree/GED	30.4 (17.4, 27.0)	37.1 (16.1, 36.6)	24.7 (16.4, 21.9)	<.0001
Percent of labor force unemployed	11.5 (6.5, 10.4)	14.0 (7.1, 11.9)	9.4 (5.1, 8.9)	<.0001
Alcohol outlet density, per square mile	8.0 (7.9, 5.8)	6.7 (6.6, 4.2)	9.2 (8.8, 6.9)	0.0003
Violent crime rate, per 1000 residents	11.2 (12.0, 9.3)	13.8 (14.9, 10.2)	9.0 (8.3, 8.8)	0.003
Population density, per square mile	5,147 (4,368, 3,904)	4,664 (3,903, 3,246)	5,560 (4,697, 4,002)	0.005
Neighborhood level^d				

	Overall (N=562)		Black (n=260)		White (n=302)		p-value
	%	(N)	%	(N)	%	(N)	
Percent of residents who are non-Hispanic Black/African-American	39.8	(30.8, 24.6)	57.2	(31.5, 57.5)	24.9	(0.21, 19.7)	< .0001
Percent of households containing a male same-sex couple	1.6	(1.6, 1.0)	1.0	(1.1, 0.5)	2.1	(1.7, 1.6)	< .0001
Male:female sex ratio	1.09	(0.41, 1.01)	0.97	(0.35, 0.90)	1.19	(0.44, 1.10)	< .0001
HIV diagnosis rate, per 100,000 residents	996.5	(801.3, 736.0)	919.7	(760.9, 658.5)	1,065	(831, 941)	0.05

^aDetermined by Fisher's exact test

^bIncludes self-reports and biomarker confirmed use

^cOptions for other non-injection drugs included: Crystal meth, crack, cocaine, downers, painkillers, hallucinogens, ecstasy, special K, GHB

^d560 of 562 participants' addresses were able to be geocoded. Violent crime rate was available for 449 of 560 residents' census tracts (206 black, 243 white). HIV diagnosis rates are missing for 42 individuals who lived in census tracts not included in the data released from the state and for 31 individuals who lived in census tracts for which the numerator (number of persons living with an HIV infection diagnosis) was less than 5 and/or the denominator (number of people in the census tract in that population group) was less than 500.

Predictors of incident HIV infection in 562 black and white non-Hispanic MSM followed in an HIV/STI incidence cohort, Atlanta, 2010–2014

Table 2

Characteristic	HIV Infections	Person-years (PY)	Incidence rate per 100 PY (95% CI)	Incidence rate ratio (95% CI)
Overall	32	843.1	3.8 (2.6, 5.4)	---
Race				
Black	24	369.2	6.5 (4.2, 9.7)	3.85 (1.67, 9.92)
White	8	473.9	1.7 (0.7, 3.3)	<i>ref.</i>
Age, current, years				
18–24	17	261.5	6.5 (3.8, 10.4)	2.52 (1.2, 5.4)
25	15	581.7	2.6 (1.5, 4.2)	<i>ref.</i>
Race and age				
Black, 18–24	16	147.5	10.9 (6.2, 17.6)	n/a
Black, 25	8	221.8	3.6 (1.6, 7.1)	
White, 18–24	1	114.0	0.9 (0.0, 4.9)	
White, 25+	7	359.9	1.9 (0.8, 4.0)	
Sexual identity				
Homosexual / gay	25	727.2	3.4 (2.3, 5.1)	<i>ref.</i>
Bisexual	7	93.4	7.5 (3.0, 15.5)	2.2 (0.80, 5.2)
Heterosexual / straight, Other	0	22.5	0.0 (0.0, 16.4)	0.0 (0.00, 5.1)
Education, baseline				
College, post-graduate, or professional school	8	408.1	2.0 (0.85, 3.9)	<i>ref.</i>
Some college, associate's degree, technical school	16	311.8	5.1 (2.9, 8.3)	2.62 (1.06, 7.07)
High school or GED, or less	8	121.3	6.6 (2.8, 13.0)	3.37 (1.10, 10.29)
Poverty, current				
Yes	9	130.1	6.9 (3.2, 13.1)	2.15 (0.87, 4.81)
No	23	713.1	3.2 (2.0, 4.8)	<i>ref.</i>
Employed, current				
Yes	24	719.2	3.3 (2.1, 5.0)	<i>ref.</i>
No	8	124.0	6.5 (2.8, 12.7)	1.93 (0.75, 4.45)
Health Insurance, baseline^a				

Characteristic	HIV Infections	Person-years (PY)	Incidence rate per 100 PY (95% CI)	Incidence rate ratio (95% CI)
Yes	14	554.8	2.5 (1.4, 4.2)	<i>ref.</i>
No	17	276.8	6.1 (3.6, 9.8)	2.43 (1.13, 5.33)
Homeless, most recent interval				
Yes	1	24.0	4.2 (0.11, 23.2)	1.10 (0.03, 6.60)
No	31	819.1	3.8 (2.6, 5.4)	<i>ref.</i>
Arrested, most recent interval				
Yes	3	21.0	14.3 (2.9, 41.8)	4.05 (0.79, 13.08)
No	29	822.1	3.5 (2.4, 5.1)	<i>ref.</i>
Recruitment site				
Atlanta venue	30	716.0	4.2 (2.8, 6.0)	<i>ref.</i>
Facebook	2	127.2	1.6 (0.19, 5.7)	0.38 (0.04, 1.48)
<i>Sexual behaviors, most recent interval</i>				
Any main partner				
Yes	15	293.6	5.1 (2.9, 8.4)	1.65 (0.77, 3.52)
No	17	549.5	3.1 (1.8, 5.0)	<i>ref.</i>
Any AI				
Yes	31	720.3	4.3 (2.9, 6.1)	5.3 (0.88, 215.5)
No	1	122.9	0.8 (0.02, 4.5)	<i>ref.</i>
Any UAI				
Yes	29	563.0	5.2 (3.4, 7.4)	4.8 (1.49, 24.67)
No	3	280.1	1.1 (0.2, 3.1)	<i>ref.</i>
Personal Behaviors				
<i>Drug use, most recent interval</i>				
Any drug use^b				
Yes	12	247.5	4.8 (2.5, 8.5)	1.44 (0.64, 3.10)
No	20	595.6	3.4 (2.1, 5.2)	<i>ref.</i>
Marijuana^b				
Yes	11	211.6	5.2 (2.6, 9.3)	1.56 (0.68, 3.39)
No	21	631.5	3.3 (2.1, 5.1)	<i>ref.</i>
Cocaine, crack-cocaine^b				

Characteristic	HIV Infections	Person-years (PY)	Incidence rate per 100 PY (95% CI)	Incidence rate ratio (95% CI)
Yes	1	98.7	1.0 (0.03, 5.6)	0.24 (0.01, 1.46)
No	31	744.4	4.2 (2.8, 5.9)	<i>ref.</i>
Methamphetamine^b				
Yes	1	23.2	4.3 (0.1, 24.0)	1.14 (0.03, 6.83)
No	31	819.9	3.8 (2.6, 5.4)	<i>ref.</i>
Poppers				
Yes	2	68.0	2.9 (0.4, 10.6)	0.76 (0.09, 2.99)
No	30	775.1	3.9 (2.6, 5.5)	<i>ref.</i>
Other non-injection (non-poppers)^c				
Yes	3	98.7	3.0 (0.6, 8.9)	0.78 (0.15, 2.52)
No	29	744.5	3.9 (2.6, 5.6)	<i>ref.</i>
Injection				
Yes	0	5.2	0.0 (0.0, 71.4)	0.0 (0.0, 19.83)
No	32	838.0	3.8 (2.6, 5.4)	<i>ref.</i>
Circumcised				
Yes	27	711.8	3.8 (2.5, 5.5)	1.00 (0.31, 5.15)
No	3	79.1	3.8 (0.8, 11.1)	<i>ref.</i>
Serodiscordant/unlk. HIV status UAI partners				
Yes	9	121.7	7.4 (3.4, 14.0)	2.32 (0.94, 5.20)
No	23	721.4	3.2 (2.0, 4.8)	<i>ref.</i>
Partner 10 years older				
Yes	10	120.1	8.3 (4.0, 15.3)	2.74 (1.16, 6.02)
No	22	723.0	3.0 (1.9, 4.6)	<i>ref.</i>
Black race partner				
Yes	21	252.6	8.3 (5.1, 12.7)	4.46 (2.06, 10.25)
No	11	590.5	1.9 (0.9, 3.3)	<i>ref.</i>
Percent living in poverty				
Neighborhood level^d < median	12	422.1	2.8 (1.5, 5.0)	<i>ref.</i>

Characteristic	HIV Infections	Person-years (PY)	Incidence rate per 100 PY (95% CI)	Incidence rate ratio (95% CI)
median	20	417.7	4.8 (2.9, 7.4)	1.68 (0.78, 3.77)
Median annual household income				
< median	20	378.3	5.3 (3.2, 8.2)	2.0 (0.95, 4.56)
median	12	461.6	2.6 (1.3, 4.5)	<i>ref.</i>
Percent of adults with high school degree/GED				
< median	13	422.5	3.1 (1.6, 5.3)	<i>ref.</i>
median	19	417.4	4.6 (2.7, 7.1)	1.48 (0.69, 3.26)
Percent of labor force unemployed				
< median	11	408.7	2.7 (1.3, 4.8)	<i>ref.</i>
median	21	431.2	4.9 (3.0, 7.4)	1.81 (0.83, 4.15)
Alcohol outlet density, per square mile				
< median	18	412.7	4.4 (2.6, 6.9)	<i>ref.</i>
median	14	427.2	3.3 (1.8, 5.5)	0.75 (0.35, 1.60)
Violent crime rate, per 1000 residents				
< median	12	313.2	3.8 (2.0, 6.7)	<i>ref.</i>
median	14	357.7	3.9 (2.1, 6.6)	1.02 (0.44, 2.42)
Population density, per square mile				
< median	14	418.5	3.3 (1.8, 5.6)	<i>ref.</i>
median	18	421.4	4.3 (2.5, 6.8)	1.28 (0.60, 2.77)
Percent of residents who are non-Hispanic Black/African-American				
< median	10	429.9	2.3 (1.1, 4.3)	<i>ref.</i>
median	22	410.0	5.4 (3.3, 8.1)	2.31 (1.05, 5.46)
Percent of households containing a male same-sex couple				
< median	17	408.5	4.2 (2.4, 6.7)	1.20 (0.56, 2.57)
median	15	431.4	3.5 (1.9, 5.7)	<i>ref.</i>
Male:female sex ratio				
< median	22	471.7	4.7 (2.9, 7.1)	1.7 (0.78, 4.06)
median	10	368.2	2.7 (1.3, 5.0)	<i>ref.</i>
HIV diagnosis rate, per 100,000 residents				

Characteristic	HIV Infections	Person-years (PY)	Incidence rate per 100 PY (95% CI)	Incidence rate ratio (95% CI)
< median	13	335.1	3.9 (2.1, 6.6)	1.04 (0.47, 2.34)
median	16	398.6	4.0 (2.3, 6.5)	ref.

^a Health insurance status missing for 1 participant with incident HIV infection

^b Includes self-reports and biomarker confirmed use

^c Options for other non-injection drugs included: Crystal meth, crack, cocaine, downers, painkillers, hallucinogens, ecstasy, special K, GHB