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Original Contribution

Sexual Networks, Dyadic Characteristics, and HIV Acquisition and Transmission Behaviors Among Black Men Who Have Sex With Men in 6 US Cities

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The role of sexual networks in the epidemiology of human immunodeficiency virus (HIV) among black men who have sex with men (MSM) is poorly understood. Using data from 1,306 black MSM in the BROTHERS Study (2009–2010) in the United States, we examined the relationships between multiple sexual dyadic characteristics and serodiscordant/serostatus-unknown condomless sex (SDCS). HIV-infected participants had higher odds of SDCS when having sex at least weekly (odds ratio (OR) = 2.41, 95% confidence interval (CI): 1.37, 4.23) or monthly (OR = 1.94, 95% CI: 1.17, 3.24) versus once to a few times a year. HIV-uninfected participants had higher odds of SDCS with partners met offline at sex-focused venues (OR = 1.79, 95% CI: 1.15, 2.78) versus partners met online. In addition, having sex upon first meeting was associated with higher odds of SDCS (OR = 1.49, 95% CI: 1.21, 1.83) than was not having sex on first meeting, while living/continued communication with sexual partner(s) was associated with lower odds of SDCS (weekly: OR = 0.64, 95% CI: 0.47, 0.85; monthly: OR = 0.60, 95% CI: 0.44, 0.81; yearly: OR = 0.58, 95% CI: 0.39, 0.85) versus discontinued communication. Persons with primary/steady nonprimary partners versus commercial partners had lower odds of SDCS regardless of HIV serostatus. This suggests the need for culturally relevant HIV prevention efforts for black MSM that facilitate communication with sexual partners especially about risk reduction strategies, including preexposure prophylaxis.

black/African-American men who have sex with men; HIV/AIDS; serodiscordant/serostatus-unknown condomless anal sex; sexual dyads; social networks; United States; urban and rural areas

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; HPTN, HIV Prevention Trials Network; MSM, men who have sex with men; OR, odds ratio; SDCS, serodiscordant/serostatus-unknown condomless sex.

In the United States, the prevalence and incidence of human immunodeficiency virus (HIV) continue to be marked by racial disparities—for example, black people account for more newly diagnosed HIV infections than any other racial/ethnic group (1). Of the incident HIV infections among black men in 2012, 71.8% occurred among men who have sex with men (MSM) (2), and black MSM aged 13–29 years are the only at-risk group among whom HIV incidence is increasing (3–5). There is a growing emphasis on the need for research studies to move from individualistic models of reported sexual behaviors to ecological frameworks that include the situational experiences and interpersonal relationships (e.g., sexual dyads) that may mitigate this epidemic (6–10).

The sexual network (i.e., collection of dyads linked directly or indirectly by sexual contact) of MSM, especially black MSM, plays an important role in HIV acquisition and transmission (11–15). Age discordance (i.e., having a younger or older sexual partner), racial mixing, and sexual partner type are 3 important sexual dyadic factors that contribute to HIV risk in black MSM. Having older male sexual partners has been shown to influence HIV acquisition in young black MSM due, in part, to the higher HIV prevalence among older black MSM (16–18), and studies have shown age discordance (i.e., sex with older partner) to be associated with HIV infection (18), although at least one study has reported a null association (19). In juxtaposition, black MSM are more

likely to have a racially homophilous sexual network (i.e., all black sexual partners) than white MSM (16, 17, 20–22), and this same-race partnering may increase susceptibility because of the prevalence (approximately 30%) of HIV-infected partners in their sexual network (17, 18). Furthermore, 32%–68% of HIV transmissions among MSM occur in the context of "main" or "primary" partnerships (23, 24). These findings suggest that there are multiple sexual dyadic characteristics that increase the susceptibility of black MSM to HIV and that researchers should consider the sexual dyad as the unit of analysis.

Recent sexual network studies among MSM report that dyadic characteristics such as age of partner, intimacy, economic influences, and power dynamics as well as concurrency and meeting partners online, at bathhouses, or clubs where sexual encounters are the norm (11, 12, 17, 25–31) influence HIV transmission and acquisition behaviors, even after adjustment for individual-level demographic factors, socioeconomic circumstances, and condom use norms/intentions. Other sexual dyadic characteristics, such as seriousness of relationship/familiarity with sexual partner (26, 27, 32), timing of anal sex with sexual partner (33), and peer norms surrounding risky sexual behaviors (34) are factors that may also increase HIV risk for black MSM. One study found that familiarity with sexual partners (defined as the number of prior sexual encounters) was associated with increased condomless anal sex among black MSM (20). In a second study among black MSM, Schneider et al. (34) demonstrated that black MSM who report having at least 1 sexual network member who does not fully disapprove of condomless anal sex were approximately 12 times as likely to engage in condomless anal sex as were men who do not have such a network member. However, the few studies among US-born black MSM that have focused on serodiscordant sex have either considered a limited number of enumerated sexual dyads (e.g., last or past 3 sexual partners) or dyadic relationship characteristics (e.g., timing and frequency of sexual encounters) (17–19, 25, 29, 33–35), and even fewer studies have focused on diverse samples of black MSM residing in different geographical locations (19, 29).

Using enumerated sexual dyadic information from the BROTHERS Study (HIV Prevention Trials Network (HPTN) 061) (36, 37), we described the typology of the sexual networks of a geographically diverse cohort of 1,553 black MSM residing in 6 US cities, and we used the sexual dyad as the (experimental) unit of analysis to investigate the associations of multiple sexual-partner demographic and relationship characteristics with serodiscordant/serostatus-unknown condomless sex (SDCS) after covarying for individual-level sociodemographic and behavioral factors.

METHODS

The BROTHERS Study (HPTN 061) was a multisite, longitudinal study designed to better understand the reasons for the disproportionate HIV burden among black MSM, and to determine the feasibility and acceptability of a multicomponent HIV prevention intervention for black MSM. The design, methods, and recruitment protocol have been described in detail elsewhere (36, 37). Briefly, using site-specific protocols, black MSM were recruited directly from the community ("community-recruited" participants) or as sexual network partners referred ("referred" participants) by index participants. At each site, the enrollment target was 250 community-recruited participants who agreed to HIV testing, with a limit of 200 HIV-negative participants, and no more than 83 participants who refused HIV testing.

Index participants were men who were: 1) previously diagnosed with HIV infection but not receiving HIV care, and having unprotected sex with partners of negative or unknown HIV status; 2) HIV-infected but unaware of their infection; or 3) HIV-uninfected. Index participants were asked to refer up to 5 of their sexual partners for enrollment in the study, with a limit of 70 referred participants per site. Those who prescreened as eligible (n = 2,639) were offered the opportunity to enroll. A total of 1,086 black MSM declined, yielding a participation rate of 58.8% (n = 1,553). The current analyses were based on data from the enrollment visit (data collected in 2009–2010). The study protocols were approved by local institutional review boards, and all participants provided signed informed consent. The current analyses were approved by the University of Mississippi Medical Center's institutional review board.

Sexual partner demographic and relationship characteristics

Trained interviewers administered the Social and Sexual Network Inventory and instructed participants to enumerate up to 5 persons on whom they could rely for functional support and up to 10 sexual partners during the 6 months prior to the enrollment visit. For each sexual partner, questions included partner demographic and relationship characteristics as well as sexual risk behaviors such as condom use. Partner demographic factors reported by the participant included age, race, sex, partner type, and perceived HIV serostatus.

Participants then reported relationship characteristics for each dyad using validated questions from previous work (38, 39). Venue where the sexual partner was met was assessed using the question "Where did you first meet _____?" Sex upon first acquaintance was assessed using the question "Did you have (anal or vaginal) sex with ____ for the first time within 12 hours of your first meeting?" Frequency of sexual encounters was based on the question "How many times did you have (anal or vaginal) sex with _____ in the past 6 months?" Social connectedness with sexual partners was based on the question "Is _____ someone that you get together with, spend time talking, relaxing or just hanging with?" Frequency of communication with each sexual partner was assessed based on the question "How often do you communicate with _____?" Geographic distance to sexual partners was based on the question "How far do you live from _____?" The respective response categories are listed in Table 1.

Table 1. Social and Sexual Network Inventory Items, Responses, and Sexual Network Classifications Among Black Men Who Have Sex With Men, BROTHERS Study (HIV Prevention Trials Network 061), United States, 2009–2010

Partner Demographic Factor	Question/Definition	Categorization of Responses	Classification of Sexual Network[a]
		Individual Characteristics	
Partner age	How old is _____? (in years)	≤17 years, 18–20 years, 21–25 years, 26–29 years, 30–40 years, 40–50 years, 50–60 years, ≥60 years	Exclusively younger Exclusively same age Exclusively older Mixed ages[b]
Partner race/ethnicity	What is _____'s race or ethnicity	Asian; black; multiracial, black; Latino; white; multiracial other; other	Exclusively black Exclusively not black Both black and not black
Partner gender	What is _____'s gender?	Male; female; male-to-female transgender; female-to-male transgender; other	Exclusively male Both male and female Transgender[c]
Partner type	What kind of sex partner is _____?	Primary; steady, nonprimary; casual; exchange or trade; anonymous	Predominantly primary Predominantly steady Predominantly casual Predominantly commercial Mixed partner types
Perceived partner HIV status	Does _____ have HIV or AIDS?	Yes; no; don't know	Exclusively known Exclusively unknown Both known and unknown
		Relationship Characteristics	
Concordance of participant-partner HIV status	Having unprotected intercourse (anal or vaginal) with a male, female or transgender sexual partner with an unknown or HIV status different from the participant's HIV status at the enrollment visit.	Concordant; serodiscordant/unknown	Exclusively concordant Exclusively serodiscordant/unknown Both concordant and serodiscordant/unknown
Venue where partner was met	Where did you first meet _____?	Met though a friend; work; school; party at a private house; social group; gym; on the internet; bar/club; private sex party; cruising area; circuit party or rave; adult bookstore; bath house or sex club; somewhere else; don't know	Predominantly online Predominantly offline sex-focused Predominantly offline not sex-focused Other/mixed venues
Sex on first acquaintance	Did you have (anal or vaginal) sex with _____ for the first time within 12 hours of your first meeting?	Yes; no	Exclusively yes Exclusively no Both yes and no
Frequency of sexual encounters	How many times did you have (anal or vaginal) sex with _____ in the past 6 months?	Daily; several times a week; weekly; several times a month; monthly; a few times; once; don't know	Exclusively at least weekly Exclusively at least monthly Exclusively a few times a year/once Mixed sexual frequencies
Social connectedness	Is _____ someone that you get together with, spend time talking, relaxing or just hanging with?	Yes; no	Exclusively social connections Exclusively social disconnections Both social connections and disconnections
Frequency of communication	How often do you communicate with _____? This could be face-to-face, phone, texting, emailing or IM-ing.	Live with; every day; a few times a week; a few times a month; about once a month; a few times a year; less than once a year; no longer see/talk/text with; ___ is ill; I no longer see; ___ has died; don't know	Live with/predominantly everyday Predominantly weekly Predominantly monthly Predominantly yearly No longer communication Mixed communication frequencies

Table continues

Table 1. Continued

Partner Demographic Factor	Question/Definition	Categorization of Responses	Classification of Sexual Network[a]
Geographic proximity to sexual partner	How far do you live from _____?	Within 1 mile; within 5 miles; within 15 miles; within 50 miles; within 100 miles; more than 100 miles; ___ is homeless; ___ lives in another country; don't know where ___ lives	Live with/predominantly ≤1 mile Predominantly within 5 miles Predominantly within 15 miles Predominantly more than 15 miles Mixed geographic distances
Condom use	How often did you use a condom when you had (anal or vaginal) sex with _____ in the past 6 months?	Always; most of the time; sometimes; never; don't know	Exclusively inconsistent Exclusively consistent Both inconsistent and consistent

Abbreviations: AIDS, acquired immunodeficiency syndrome; HIV, human immunodeficiency virus; IM, instant message.

[a] A characteristic was operationalized as exclusive if all (100%) of the responses were for a given response category (e.g., all black sexual partners). A characteristic was operationalized as predominant when a question had three or more response categories and one response category had the greatest proportion of responses relative to the other response categories. For example, if a participant enumerated 4 sexual partners and enumerated 2 primary partners (50%), 1 casual partner (25%), and 1 commercial partner (25%), then this participant was classified as having a predominantly primary sexual-partner typology. A characteristic was operationalized as mixed/both when 2 or more response categories equally had the greatest proportion of responses (i.e., participant provided different responses across sexual partners and no single response category had the greatest proportion of responses). The number of sexual partners was calculated by summing the number of enumerated sexual partners, which was capped at 10 based on the limit of 10 sexual partners that a participant was able to enumerate in the Social and Sexual Network Inventory.

[b] Participant-partner age differential was calculated as the categorical difference between the participant's and sex partner's age: younger, same age, or older.

[c] Participant indicating having at least 1 transgender sexual partner.

Serodiscordant or serostatus-unknown condomless sex

All participants underwent rapid HIV testing after risk reduction counseling. Reactive tests were confirmed in real time by Western blot testing at study sites and retrospectively by quality assurance testing at the HPTN Laboratory Center (Johns Hopkins University, Baltimore, Maryland). Subsequent testing was performed to detect antiretrovirals in a subset of participants with a reactive HIV test; if antiretrovirals consistent with antiretroviral treatment were detected, participants were classified as previously diagnosed (40). In sum, participants were categorized as previously diagnosed HIV-infected (either by self-report or by antiretroviral testing), newly diagnosed HIV-infected, or HIV-uninfected. SDCS was defined as having condomless (inconsistent condom use: most of the time, sometimes, or never) anal or vaginal sex with a serodiscordant or serostatus-unknown male, female, or transgender sexual partner, and it was dichotomized as any or no SDCS in the 6 months prior to study enrollment. Specifically, for HIV-uninfected participants, SDCS was defined as having condomless sex with an HIV-infected or unknown-serostatus partner, and for HIV-infected participants, SDCS was defined as having condomless sex with an HIV-uninfected or unknown-serostatus partner.

Standard covariates

Standard covariates included participant age, sex, race, ethnicity, HIV serostatus, sexual orientation, socioeconomic status, history of incarceration, unstable housing, whether the participant travelled to other cities for sex (yes or no), and HPTN study site. Educational attainment, current student status, annual household income, employment status, and marital status were used to characterize socioeconomic status.

Statistical analysis plan

Sexual partner demographic and relationship characteristics and HIV transmission and acquisition behaviors were aggregated to categorize sexual network measures as exclusive, predominant, or mixed/both based upon the proportion of responses for a given response category. Details are provided in Table 1. The number of sexual partners was calculated by summing the total number of enumerated sexual partners, which was capped at 10 based on the limit of 10 sexual partners that a participant was able to enumerate in the Social and Sexual Network Inventory. The number of sexual partners was trichotomized as 1, 2–3, and 4 or more sexual partners based on tertile distribution, as well as dichotomized as single versus multiple sexual partners. Prior work documents differential relationships between sexual dyadic characteristics and HIV risk by HIV serostatus (25) because awareness of one's HIV status may influence the selection of sexual partners and sexual risk behaviors. Therefore, we stratified all analyses by participant HIV serostatus. In descriptive analyses, we examined the distribution of selected participant and sexual network characteristics by HIV serostatus and tested differences using χ^2 and t tests. We estimated the probability of sexual dyadic

characteristics (partner demographic and relationship measures) as well as the probability of SDCS according to participant HIV serostatus using intercept-only logistic generalized estimating equation models with sexual dyads (repeated measures) nested within participants. We tested for differences by HIV serostatus by including participant HIV serostatus in the regression model as a nominal variable. Next, we evaluated the bivariate associations of sexual partner demographic and relationship characteristics with SDCS in unadjusted models (model 1). Variables that were marginally significant ($P < 0.10$) in model 1 were considered in the multivariable regression analyses (model 2). The full-adjustment multivariable model (model 3) further included model 2 for the standard individual-level covariates. "Unknown" and "Don't Know" responses for frequency of communication and geographic proximity were coded as a separate category ("Other") so that the sexual dyad could be retained in regression analyses. Hypothesis testing was 2-sided with a nominal type I error rate of 0.05; all statistical analyses were performed using SAS, version 9.3 (SAS Institute, Inc., Cary, North Carolina), and generalized estimating equation models were fitted using the PROC GENMOD procedure.

RESULTS

Of the 1,553 participants who completed the BROTHERS Study enrollment visit, 247 were excluded because of missing (19) or incomplete (45) Social and Sexual Network Inventory data, reporting only female sex partners (46), being newly HIV-infected at enrollment (86), refusing HIV testing/having no blood sample to confirm HIV infection status (33) (37), or missing data on covariates (18). There were 1,306 participants (84.1% of those who attended the enrollment visit) with a mean age of 37.6 (standard deviation, 11.8) years in the analytical sample. At the enrollment visit, 17.7% were known to be previously diagnosed HIV-infected and 82.3% were confirmed HIV-uninfected (Table 2). Compared with previously diagnosed HIV-infected participants, HIV-uninfected participants were younger and more likely to report being bisexual and having current employment (part-time or full-time) and unstable housing.

HIV-uninfected participants reported more sexual partners in their sexual network (in the past 6 months) than did previously diagnosed HIV-infected participants (Table 3), and HIV-uninfected participants were less likely to report being monogamous (1 sexual partner in the past 6 months) and having sexual networks with exclusively younger, exclusively black, and exclusively male sexual partners ($P < 0.01$ for all). HIV-uninfected participants were also more likely to report having exclusively HIV-concordant sexual networks than previously diagnosed HIV-infected participants ($P < 0.001$). Compared with previously diagnosed HIV-infected participants, HIV-uninfected participants were less likely to engage in sex on first acquaintance or at least weekly with members of their sexual network ($P < 0.05$ for all).

Participants reported information on 4,260 sexual dyads in the 6 months prior to the enrollment visit. The probabilities that participants would select black and male partners were 0.692 and 0.787, respectively (Table 4). One in 3 partners were primary (0.154) or steady nonprimary (0.188) partners, and participants were unaware or unsure of the HIV status of nearly 1 in 2 (0.406) of their sexual partners. The probability that participants engaged in sex with their partners once to

Table 2. Distribution of Selected Participant Characteristics at Baseline According to HIV Infection Status Among Black Men Who Have Sex With Men, BROTHERS Study (HIV Prevention Trials Network 061), United States, 2009–2010

Characteristic	Total (n = 1,306)	HIV-Infected (n = 231)	HIV-Uninfected (n = 1,075)
Mean age and SD, years	37.8 (11.8)	42.4 (9.1)	36.8 (12.1)[a]
Latino/Hispanic, %	7.7	6.5	8.0
Sexual orientation, %			
Homosexual/gay	28.8	38.5	26.7[a]
Bisexual	27.9	20.4	29.5
Refused/unknown	43.3	41.1	43.8
Transgender, %	1.8	2.6	1.7
Less than a high school diploma or equivalent, %	16.9	13.9	17.5
Current student (part-time or full-time), %	21.1	19.5	21.5
Annual household income less than $10,000, %	37.5	36.8	37.7
Not currently working, %	68.5	82.3	65.6[a]
Main partner/married/legal partnership, %	11.4	10.8	11.5
History of incarceration, %	59.7	63.4	58.9
Unstable housing, %	9.5	5.6	10.3[b]
Travel to other cities for sex, %	32.3	32.5	32.3

Abbreviations: HIV, human immunodeficiency virus; MSM, men who have sex with men; SD, standard deviation.
[a] $P < 0.001$ for differences compared with HIV-infected MSM.
[b] $P < 0.05$ for differences compared with HIV-infected MSM.

Table 3. Sexual Network-Level Characteristics at Baseline According to HIV Infection Status Among Black Men Who Have Sex With Men, BROTHERS Study (HIV Prevention Trials Network 061), United States, 2009–2010

Characteristic	Total (n = 1,306)	HIV-Infected (n = 231)	HIV-Uninfected (n = 1,075)
Mean no. (SD) of partners	3.3 (2.1)	2.8 (2.0)	3.4 (2.2)[a]
% Reporting 1	20.8	31.6	18.5[a]
% Reporting 2–3	43.7	43.7	43.7
% Reporting ≥4	35.5	24.7	37.8
Partner age, %			
Exclusively younger	29.9	38.1	28.2[b]
Exclusively same age	12.5	14.7	12.0
Exclusively older	8.3	7.4	8.5
Mixed ages	49.3	39.8	51.4
Partner race, %			
Exclusively black	55.3	68.0	52.6[a]
Exclusively not black	14.1	10.4	14.9
Both black and not black	30.6	21.7	32.6
Partner gender/identity, %			
Exclusively male	67.2	82.7	63.8[a]
Both male and female	25.3	13.4	27.8
Transgender	7.6	3.9	8.4
Partner type, %			
Predominantly primary	14.1	18.2	13.2
Predominantly steady	10.4	10.0	10.5
Predominantly casual	41.9	43.7	41.5
Predominantly commercial	10.5	8.2	11.0
Mixed partner types	23.1	19.9	23.8
Perceived partner HIV infection status, %			
Exclusively known	48.2	43.3	49.2
Exclusively unknown	21.8	26.4	20.8
Both known and unknown	30.0	30.3	30.0
Concordance of partner HIV-infection serostatus, %			
Exclusively concordant	41.6	26.0	44.9[a]
Exclusively serodiscordant/unknown	28.3	43.7	24.9
Both concordant and serodiscordant/unknown	30.2	30.3	30.1
Venue where partner was met, %			
Predominantly online	10.8	9.5	11.1
Predominantly offline sex-focused	7.3	8.7	7.0
Predominantly offline not sex-focused	44.3	43.7	44.5
Other (somewhere else)/mixed venues	37.6	38.1	37.5
Sex during first acquaintance, %			
Exclusively yes	13.6	17.8	12.7[c]
Exclusively no	43.0	45.9	42.3
Both yes and no	43.5	36.4	45.0

Table continues

Table 3. Continued

Characteristic	Total (n = 1,306)	HIV-Infected (n = 231)	HIV-Uninfected (n = 1,075)
Frequency of sexual encounters, %			
Exclusively at least weekly	13.6	18.6	12.5[a]
Exclusively at least monthly	12.5	16.5	11.6
Exclusively a few times/once	58.4	50.7	60.1
Mixed frequency of sexual encounters	15.5	14.3	15.8
Social connectedness, %			
Exclusively social connections	36.8	42.0	35.7[d]
Exclusively social disconnections	15.5	17.3	15.1
Both social connections and disconnections	47.7	40.7	49.2
Frequency of communication, %			
Live with or predominantly every day	19.5	23.4	18.6
Predominantly weekly	13.6	14.7	13.3
Predominantly monthly	19.9	21.7	19.5
Predominantly yearly	2.7	2.6	2.7
No longer communicate	13.9	11.3	14.5
Mixed frequency of communication	24.8	21.2	25.6
Other[e]	5.7	5.2	5.7
Geographic proximity, %			
Live with or predominantly ≤1 mile	16.6	20.4	15.8
Predominantly within 5 miles	17.1	16.5	17.2
Predominantly within 15 miles	23.4	19.5	24.3
Predominantly >15 Miles	0.0	0.0	0.0
Mixed geographic proximities	30.3	31.2	30.1
Other[e]	12.6	12.6	12.7
Condom use, %			
Exclusively inconsistent	34.7	35.5	34.6
Exclusively consistent	30.1	33.8	29.3
Both inconsistent and consistent	35.2	30.7	36.1

Abbreviations: HIV, human immunodeficiency virus; MSM, men who have sex with men; SD, standard deviation.
[a] $P < 0.001$ for differences compared with previously HIV-diagnosed MSM.
[b] $P < 0.01$ for differences compared with previously HIV-diagnosed MSM.
[c] $P < 0.05$ for differences compared with previously HIV-diagnosed MSM.
[d] $P < 0.10$ for differences compared with previously HIV-diagnosed MSM.
[e] Includes "Unknown" or "Don't know" responses.

a few times a year was 0.637, and the estimated probability that a sexual relationship was serodiscordant or serostatus unknown was 0.466. These estimates varied slightly according to participant HIV serostatus.

The overall predicted probability of SDCS was 0.324 (i.e., nearly one-third of all sexual dyads in the 6 months prior to the enrollment visit involved potential HIV acquisition or transmission behaviors), with the probability of SDCS being higher among previously diagnosed HIV-infected participants (0.449) than HIV-uninfected participants (0.301) ($P < 0.001$).

Among previously diagnosed HIV-infected participants (Table 5), participants had lower odds of SDCS with primary (odds ratio (OR) = 0.43, 95% confidence interval (CI): 0.21, 0.90) and steady nonprimary (OR = 0.44, 95% CI: 0.21, 0.92) partners compared with commercial partners, even after adjustment for individual-level sociodemographic factors, socioeconomic circumstances, and study site (model 3). Having sex at least weekly (OR = 2.41, 95% CI: 1.37, 4.23) or monthly (OR = 1.94, 95% CI: 1.17, 3.24) compared with having sex with partners once to a few times a year was associated with higher odds of SDCS among previously diagnosed HIV-infected participants. Previously diagnosed HIV-infected participants had lower odds of SDCS when living with or communicating with their partners at least weekly (OR = 0.55, 95% CI: 0.33, 0.90), but this association did not persist in full-adjustment models (model 3).

HIV-uninfected participants had higher odds of SDCS with younger partners (OR = 1.37, 95% CI: 1.07, 1.56) compared

Table 4. Probability of Partner Demographic and Relationship Characteristics According to HIV Infection Status Among Black Men Who Have Sex With Men, BROTHERS Study (HIV Prevention Trials Network 061), United States, 2009–2010

Characteristic	Probability		
	Total (n = 4,206)	Partner of HIV-Infected Participants (n = 653)	Partner of HIV-Uninfected Participants (n = 3,607)
Age			
Younger	0.496	0.564	0.484[a]
Same age	0.202	0.136	0.214[b]
Older	0.302	0.300	0.302
Race			
Black	0.692	0.792	0.675[c]
White	0.141	0.077	0.152[c]
Latino	0.124	0.100	0.128[d]
Other	0.043	0.032	0.045
Sex			
Male	0.787	0.896	0.768[c]
Female	0.172	0.078	0.189[c]
Transgender	0.040	0.026	0.043
Partner type			
Primary	0.154	0.172	0.151
Steady, nonprimary	0.188	0.155	0.194[a]
Casual	0.496	0.551	0.486[a]
Commercial	0.162	0.123	0.170[a]
Perceived HIV infection status			
HIV-negative	0.514	0.204	0.570[c]
HIV-positive	0.080	0.331	0.034[c]
Unknown/unsure	0.406	0.466	0.396[a]
Venue where partner was met			
Online	0.148	0.150	0.147
Offline, sex-focused	0.101	0.101	0.101
Offline, not sex-focused	0.481	0.459	0.485
Other (somewhere else)	0.271	0.289	0.268
Sex upon first acquaintance	0.396	0.417	0.392
Frequency of sexual encounters			
Weekly	0.166	0.185	0.163[b]
Monthly	0.197	0.225	0.192
A few times/once	0.637	0.590	0.645
Social connectedness	0.579	0.602	0.574
Frequency of communication			
Live with or every day	0.445	0.485	0.438
Weekly	0.290	0.700	0.288
Monthly	0.063	0.058	0.064
Yearly/no longer communicate	0.195	0.144	0.204
Other[d]	0.015	0.012	0.006
Geographic proximity			
Live with or ≤1 mile	0.196	0.228	0.190
Within 5 miles	0.224	0.214	0.226
Within 15 miles	0.252	0.237	0.254
More than 15 miles	0.204	0.201	0.204
Other[d]	0.125	0.478	0.268

Table continues

Table 4. Continued

Characteristic	Probability		
	Total (n = 4,206)	Partner of HIV-Infected Participants (n = 653)	Partner of HIV-Uninfected Participants (n = 3,607)
Inconsistent condom use	0.702	0.741	0.695[e]
Serodiscordant/unknown HIV status	0.466	0.634	0.435[c]

Abbreviations: HIV, human immunodeficiency virus; MSM, men who have sex with men.
[a] $P < 0.05$ for differences compared with previously HIV-diagnosed MSM.
[b] $P < 0.01$ for differences compared with previously HIV-diagnosed MSM.
[c] $P < 0.001$ for differences compared with previously HIV-diagnosed MSM.
[d] Includes "Unknown" or "Don't know" responses.
[e] $P < 0.10$ for differences compared with previously HIV-diagnosed MSM.

with older partners, but this association was attenuated after adjustment for the standard covariates. Compared with black sexual partners, HIV-uninfected participants had lower odds of SDCS with Latino/Hispanic (OR = 0.62, 95% CI: 0.47, 0.82) and other racial/ethnic (OR = 0.62, 95% CI: 0.41, 0.94) partners. However, these associations did not persist in full-adjustment models (model 3). HIV-uninfected participants also had lower odds of SDCS with primary (OR = 0.49, 95% CI: 0.33, 0.73) and steady nonprimary (OR = 0.53, 95% CI: 0.36, 0.78) partners, compared with commercial partners. Meeting partners offline at sex-focused venues (OR = 1.79, 95% CI: 1.15, 2.78), rather than online, as well as having sex early when meeting sexual partners (OR = 1.49, 95% CI: 1.21, 1.83), rather than not having sex on first meeting, were associated with higher odds of SDCS. Living with/communicating with partner(s) at least weekly (OR = 0.64, 95% CI: 0.47, 0.85), monthly (OR = 0.60, 95% CI: 0.44, 0.81), or yearly (OR = 0.58, 95% CI: 0.39, 0.85), compared with discontinued communication, was associated with lower odds of SDCS among HIV-uninfected participants.

DISCUSSION

To our knowledge, this is the first study to characterize the sexual networks of black MSM and is one of the first to use enumerated sexual network information to investigate how multiple sexual partner and relationship characteristics are concomitantly and independently related to HIV acquisition and transmission behaviors in a large, geographically diverse cohort of black MSM. First, we observed differences in the sexual networks of black MSM according to HIV serostatus. HIV-uninfected MSM reported more sexual partners in their sexual network (in the past 6 months) than previously diagnosed HIV-infected participants; however, HIV-uninfected participants were more likely to report sexual networks containing members with concordant HIV serostatus and were less likely to report sexual networks that contained only younger, black, and male sexual partners. Second, and consistent with prior work (31), we found lower odds of SDCS with primary and steady nonprimary sexual partners, irrespective of HIV serostatus, even after adjustment for individual-level sociodemographic characteristics and study site. Third, among previously diagnosed HIV-infected men, we found higher odds of possible HIV-transmission behaviors when sexual dyads engaged in frequent (at least monthly) sexual encounters. Fourth, among HIV-uninfected men, we demonstrated that meeting sexual partners at sex-focused venues (not online) and engaging in sex upon first acquaintance were associated with higher odds of HIV risk. Last, continued communication with a sexual partner was associated with lower odds of SDCS among HIV-uninfected men.

In a study of black MSM residing in Milwaukee, Wisconsin; Cleveland, Ohio; and Miami, Florida, Kelly et al. (29) demonstrated that black MSM engaged in more acts of condomless anal sex with main partners than nonmain partners, which is inconsistent with findings in the current study. Black MSM have been shown to talk with their main and casual sexual partners about their HIV status rather than with exchange sexual partners (41), and they may make sexual decisions based on their beliefs about the HIV status of their sexual partners or their dependency for finances or other supports from their sexual partners (42). Commercial/sex exchange–type relationships may also occur in poor economic areas, especially in areas with high drug use, and may result in power differentials that hinder communication about HIV serostatus and the negotiation of condom use (43). Washington and Meyer-Adams (44) reported limited to no condom use during sex trade among injection drug–using black MSM in Baltimore, Maryland, and Kong et al. (45) reported a similar finding among Chinese MSM. This highlights the need for structural interventions that promote communication about the use of condoms, regardless of partner type, and HIV testing and disclosure of HIV serostatus as well as job training and employment opportunities for black MSM.

The timing and number of sexual acts during a sexual relationship may influence HIV acquisition and transmission behaviors in MSM (45, 46). First, a recent study among Chinese MSM demonstrated that MSM were likely to engage in condomless sex in an emotionally intimate, stable, and committed relationship (45). Second, researchers have demonstrated a positive association between the number of

Table 5. Sexual Partner Demographic and Relationship Characteristics of Any Serodiscordant/Serostatus-Unknown Condomless Anal Sex According to HIV Infection Status Among Black Men Who Have Sex With Men, BROTHERS Study (HIV Prevention Trials Network 061), United States, 2009–2010

Characteristic	HIV-Infected						HIV-Uninfected					
	Model 1[a]		Model 2[b]		Model 3[c]		Model 1[a]		Model 2[b]		Model 3[c]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Partner Demographic Characteristics												
Age												
Younger age	1.60[d]	0.93, 2.74	1.53	1.89, 2.64			1.37[e]	1.07, 1.56	1.31[e]	1.00, 1.67	0.90	0.68, 1.18
Same age	1.42	0.82, 2.47	1.37	0.77, 2.43			1.06	0.84, 1.33	1.16	0.91, 1.48	0.99	0.78, 1.27
Older age	1.00	Referent	1.00	Referent			1.00	Referent	1.00	Referent	1.00	Referent
Gender/identity												
Male	1.00	Referent					1.00	Referent				
Female	0.86	0.44, 1.69					1.02	0.80, 1.32				
Transgender	1.76	0.41, 7.61					1.46	0.91, 2.34				
Race												
Black	1.00	Referent					1.00	Referent	1.00	Referent	1.00	Referent
White	1.24	0.63, 2.43					1.10	0.83, 1.46	0.98	0.75, 1.29	1.58[d]	1.00, 2.52
Latino	1.00	0.53, 1.89					0.62[g]	0.47, 0.82	0.53[f]	0.40, 0.71	0.91	0.57, 1.45
Other	0.76	0.37, 1.57					0.62[e]	0.41, 0.94	0.56[f]	0.36, 0.86	0.71	0.46, 1.10
Partner type												
Primary	0.47[e]	0.26, 0.85	0.38[e]	0.18, 0.77	0.43[e]	0.21, 0.90	0.27[g]	0.20, 0.39	0.40[g]	0.26, 0.62	0.49[g]	0.33, 0.73
Steady, nonprimary	0.45[e]	0.24, 0.86	0.41[e]	0.20, 0.87	0.44[e]	0.21, 0.92	0.28[g]	0.20, 0.39	0.45[g]	0.30, 0.67	0.53[g]	0.36, 0.78
Casual	0.75	0.44, 1.26	0.79	0.45, 1.38	0.76	0.43, 1.35	0.52[g]	0.40, 0.69	0.78	0.57, 1.05	0.82	0.61, 1.11
Commercial	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Relationship Characteristics												
Venue where partner was met												
Online	1.00	Referent					1.00	Referent	1.00	Referent	1.00	Referent
Offline, sex-focused venues	1.53	0.74, 3.18					3.64[g]	2.37, 5.59	2.51[g]	1.61, 3.92	1.79[f]	1.15, 2.78
Offline, not sex-focused venues	0.88	0.51, 1.51					1.50[e]	1.09, 2.07	1.57[f]	1.13, 2.19	1.25	0.90, 1.74
Somewhere else	0.79	0.43, 1.45					1.78[f]	1.26, 2.51	1.72[f]	1.20, 2.48	1.17	0.81, 1.69
Sex upon first acquaintance												
Yes	1.19	0.85, 1.67					1.86[g]	1.54, 2.26	1.45[g]	1.18, 1.79	1.49[g]	1.21, 1.83
No	1.00	Referent					1.00	Referent	1.00	Referent	1.00	Referent
Frequency of sexual encounters												
At least weekly	1.53[d]	0.96, 2.43	2.45[f]	1.38, 4.32	2.41[f]	1.37, 4.23	0.66[f]	0.51, 0.84	1.07	0.79, 1.45		
At least monthly	1.47[d]	0.95, 2.28	2.00[f]	1.21, 3.32	1.94[e]	1.17, 3.24	0.85	0.67, 1.08	1.09	0.85, 1.41		
A few times/once	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent		

Table continues

Table 5. Continued

Characteristic	HIV-Infected						HIV-Uninfected					
	Model 1[a]		Model 2[b]		Model 3[c]		Model 1[a]		Model 2[b]		Model 3[c]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Social connectedness												
Yes	0.83	0.57, 1.20					0.66[g]	0.55, 0.79	1.07	0.85, 1.34		
No	1.00	Referent					1.00	Referent	1.00	Referent		
Frequency of communication												
Live with/at least weekly	0.55[e]	0.33, 0.90	0.61[d]	0.34, 1.08	0.56[d]	0.30, 1.04	0.46[g]	0.36, 0.58	0.67[e]	0.50, 0.91	0.64[f]	0.47, 0.85
At least monthly	0.74	0.44, 1.26	0.75	0.42, 1.36	0.72	0.38, 1.38	0.51[g]	0.39, 0.67	0.63[f]	0.46, 0.85	0.60[g]	0.44, 0.81
At least yearly	0.59	0.25, 1.38	0.69	0.29, 1.67	0.64	0.25, 1.60	0.62[e]	0.42, 0.91	0.67[e]	0.45, 0.99	0.58[f]	0.39, 0.85
No longer communicate	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Other (unknown)	0.48	0.08, 2.87	0.60	0.07, 4.86	0.60	0.09, 3.85	3.09[e]	1.04, 9.16	2.46	0.74, 8.23	2.66	0.74, 9.57
Geographic proximity												
Live within <1 mile	0.89	0.50, 1.61					1.13	0.85, 1.50	1.28	0.95, 1.73	1.24	0.92, 1.66
Within 5 miles	0.97	0.55, 1.71					1.21	0.91, 1.60	1.22	0.91, 1.63	1.14	0.85, 1.53
Within 15 miles	0.75	0.42, 1.33					1.29[d]	0.98, 1.69	1.27[d]	0.97, 1.68	1.20	0.92, 1.58
>15 miles	1.00	Referent					1.00	Referent	1.00	Referent	1.00	Referent
Other (unknown)	2.18[f]	1.21, 3.94					2.76[g]	1.99, 3.81	1.48[e]	1.04, 2.10	1.35	0.95, 1.92

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; HPTN, HIV Prevention Trials Network; MSM, men who have sex with men; OR, odds ratio.

[a] Model 1: unadjusted, in separate models.

[b] Model 2: multivariable, adjustment for marginally significant ($P < 0.10$) variables in model 1.

[c] Model 3: full model, adjustment for significant variables in model 2 and standard covariates: participant age, race, Latino/Hispanic ethnicity, HIV infection status, sex, sexual orientation, education, current student status, income, employment status, marital status, history of incarceration, unstable housing, travel to other cities for sex, and HPTN study site.

[d] $P < 0.10$.

[e] $P < 0.05$.

[f] $P < 0.01$.

[g] $P < 0.001$.

anal sexual episodes and the rate of condomless anal sex in a cross-sectional study among MSM in Soweto, South Africa (32) but not in a multiethnic sample of 4,295 HIV-uninfected MSM in the EXPLORE Study (47). The findings in the present study suggest that previously diagnosed HIV-infected black MSM are largely inconsistent in their condom use across sexual acts (frequent encounters or early upon meeting). Among previously diagnosed HIV-infected black MSM, frequent sexual encounters may allow one to become familiar with his sexual partner(s), and familiarity with sexual partners has been shown to be associated with increased likelihood of condomless anal sex (20, 48). On the other hand, HIV-uninfected black MSM may perceive a lower HIV risk with their sexual partners, including first-time meeting partners and meeting partners at sex-focused venues, and make condom-use decisions based on these perceptions (42) and partner sexual desirability (49). Consequently, interventions such as the clinic-based "Focus on the Future" intervention (50) are needed to address the individual, interpersonal, and structural constructs that promote correct and consistent condom use in black MSM.

Meeting partners online has long been considered as a sexual risk factor that propagates sex among MSM, and men who met partners online reported high levels of condomless sex and sexually transmitted infections (51). More important, recent reports have implicated online dating sites and social geospatial networking applications such as Grindr and Jack'd in the increase in sexually transmitted infections in certain regions of the United States (52). However, the results in the published literature are mixed: one study demonstrated significantly less condomless sex with partners met online (53), while 2 other studies showed no difference in sexual risk behaviors between partners met online or offline (27, 54). Qualitative research studies show that young MSM have a greater mistrust of partners met online and a greater desire to use condoms with them compared with partners met in other venues (55), which aligns with the results in our study that indicate that HIV-uninfected black MSM have a higher odds of condomless sex with serodiscordant or serostatus-unknown sexual partners met offline in sex-focused (e.g., bathhouses or sex parties) and not-sex-focused (e.g., met through a friend or acquaintance) venues compared with sexual partners met online. More work is needed to better understand partner-seeking behaviors and HIV-acquisition risk among HIV-uninfected black MSM.

Communication about HIV risk-reduction strategies, including serosorting and effective and consistent condom use, may lead to protective sexual behaviors among MSM (56). A study in HIV-infected and HIV-uninfected Latino MSM documented a positive association between communication about condom use and protected anal intercourse during the most recent sexual encounter (57), although the investigators did not explore heterogeneities in study findings by HIV serostatus. To our knowledge, our study is the first to document an association between ongoing communication with sexual partners and SDCS among previously diagnosed HIV-infected and HIV-uninfected black MSM, although the association among previously diagnosed HIV-infected black MSM did not persist in full-adjustment models. We cannot rule out the possibility that men in the present study are disclosing their HIV serostatus as well as communicating with members of their sexual network about the use of condoms. Additional research is needed to replicate the findings in the present study and to explore interpersonal aspects of communication between sexual partners, peers, and other social network members about condom use, serosorting, and other risk-reduction strategies among black MSM.

A major strength of the current study is the consideration of enumerated sexual dyads (in a sexual network) as a potential source of HIV acquisition or transmission if the partner's HIV status was unknown or different from the participant's HIV status. Other strengths include the examination of the associations between multiple sexual-partner demographic factors, relationship characteristics, and SDCS; the geographic diversity of the study sample; and a large sample to allow adjustment for several potential confounders. Limitations include the use of self-reported and recalled data, the potentiality of inaccurate information collected about commercial and anonymous partners, the cross-sectional study design, and the focus on recruiting HIV-infected men who were unaware of their status and men who were HIV-infected but not in care and who reported condomless sex with uninfected partners or partners of unknown status, which may potentially skew our results. The study sample consisted only of black MSM; therefore, the results may not be generalizable to MSM of other races/ethnicities or to heterosexual populations.

The findings in the current study suggest that HIV-prevention efforts should focus on reducing sexual risk behaviors with commercial (anonymous/exchange) sexual partners as well as addressing consist condom use across sexual encounters among black MSM. Longitudinal studies focused on sexual dyads, as well as investigating how sexual dyads may vary over time, are needed to fully elucidate the putative mechanisms linking sexual dyads to HIV infection in this high-risk population (58, 59). Furthermore, the high proportion of SDCS reported by black MSM participating in this study underscores the need to assure access to biobehavioral HIV prevention and care services, including HIV preexposure prophylaxis for those who are HIV-uninfected or at risk, as well as research focused on communication with sexual partners about HIV serostatus, the use of condoms, serosorting, and other-risk reduction strategies.

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