Reciprocal Sex Partner Concurrency and STDs among Heterosexuals at High-Risk of HIV Infection

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ABSTRACT *Inconsistent findings on the relationship of sex partner concurrency to infection with HIV and other sexually transmitted diseases (STDs) may result from differences in how sex partner concurrency is conceptualized. We examine the relationship of reciprocal sex partner concurrency (RSPC) to diagnosed STDs among heterosexuals. Heterosexually active adults (N=717) were recruited for a cross-sectional study using respondent-driven sampling (RDS) from high-HIV-risk areas in New York City (NYC, 2006–2007) and interviewed about their sexual risk behaviors, number of sex partners, last sex partners, and STD diagnoses (prior 12 months). RSPC was when both the participant and her/his last sex partner had sex with other people during their sexual relationship. Odds ratios (OR), adjusted odds ratios (aOR), and 95 % confidence intervals (95%CI) were estimated by logistic regression. The sample was 52.4 % female, 74.3 % Black; median age was 40 years. RSPC was reported by 40.7 % and any STD diagnoses by 23.4 %. Any STDs was reported by 31.5 % of those reporting RSPC vs. 17.9 % of those who did not (OR=2.11, 95%CI=1.49–3.0). Any STDs was independently associated with RSPC (aOR=1.54, 95%CI=1.02–2.32), female gender (aOR=2.15, 95%CI=1.43–3.23), having more than three sex partners (aOR=1.72, 95%CI=1.13–2.63), and unprotected anal sex (aOR=1.65, 95%CI=1.12–2.42). Heterosexuals in high-HIV-risk neighborhoods in sexual partnerships that involve RSPC are at greater risk of STDs and, potentially, HIV. RSPC, in addition to sexual risk behaviors and the number of sex partners, may facilitate the heterosexual spread of HIV through STD cofactors and linkage into larger STD/HIV sexual transmission networks.*

KEYWORDS *Heterosexuals, HIV, Sex partner concurrency, STDs, New York City*

INTRODUCTION

A high proportion of HIV diagnoses in the United States are attributable to heterosexual transmission. In 2008, heterosexual transmission accounted for 32 % of new diagnoses in the 37 states with confidential name-based HIV

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infection reporting¹ and 22 % in New York City (NYC).² Understanding the risk factors for heterosexual transmission is essential for prevention. However, individual risk behaviors, such as condom use and the number of sex partners, and sexually transmitted disease (STD) cofactors do not by themselves explain the heterosexual spread of HIV.^{3,4} In addition to these risk factors, the characteristics of sexual networks among heterosexuals,⁵ specifically the pattern of sex partner concurrency (overlapping sex partnerships in the same time interval), may help to explain the heterosexual spread of HIV and other STDs in sub-Saharan Africa^{6–8} and in high-risk urban and rural areas in the United States.^{9–11}

A high prevalence of sex partner concurrency in a population has been hypothesized to increase the number of direct or indirect sexual connections and thereby to influence the extent, rapidity, and persistence of HIV and other STD epidemics.¹² However, the theory that sex partner concurrency is a driver of heterosexual HIV epidemics has been criticized for being based on limited evidence.^{13,14} Here, we propose that inconsistent findings on the relation of sex partner concurrency to HIV and STD epidemics may be a function of how the concept is specified and that sex partner concurrency may refer to different patterns of overlapping sex partnerships. In particular, we make a distinction between mono concurrency and reciprocal concurrency. This is described below and in Figure 1 for heterosexual partners.

Mono concurrency occurs when an index individual has two or more partners during the same time interval and these partners do not have other partners. In Figure 1, under mono concurrency, index A, a male, has two female partners, B and C, who do not have other partners. Reciprocal concurrency occurs when the index and one or more concurrent sex partners have other sex partners during the same time interval. In Figure 1, under reciprocal concurrency, B, a female partner of A, reports male partners D and E. In mono concurrency, if index A is uninfected, the risk of A becoming infected would arise if B or C was infected and A engaged in unprotected sex with B or C. In reciprocal concurrency, the risk to A is increased because B and/or C are

FIGURE 1. Mono and reciprocal concurrency in heterosexual partnerships.

linked to other partners and may be part of a larger sexual transmission network with more paths through which infectious pathogens can flow.

Reciprocal concurrency may be common among those with concurrent partners. In population-based studies of men and women in the United States, having concurrent sex partners was independently associated with having sex partners who were themselves nonmonogamous.^{15,16} Studies on network factors associated with the risk of infection with HIV and other STDs have shown that risk networks comprising direct and indirect ties among members (termed “sociocentric”⁶ or “sociometric”¹⁷ networks) influence the risk of infection, e.g., among injection drug users (IDU), men who have sex with men (MSM), sex workers, and at-risk rural and urban populations in sub-Saharan Africa.^{6,17–22}

It is often difficult and not feasible to sample, recruit, and measure sociocentric networks.²³ Another approach is to use egocentric network data (the direct relationships of an index individual [ego] with other individuals, e.g., sexual partners), whether directly measured or through self-report, to develop proxy measures of sociocentric network characteristics.^{24,25} In the following, we use self-reported egocentric data on recent sexual partnerships from a risk behavior survey of heterosexuals at high risk of HIV in NYC to examine the prevalence and correlates of reciprocal sex partner concurrency (RSPC) and its relationship to STDs. Although the relationship between STD infection and the sexual transmission of HIV is complex, STDs can be both biological cofactors and markers of greater sexual risk for HIV infection in vulnerable populations.^{26–29}

METHODS

Sampling, Eligibility, Data Collection

The data for this analysis are from the National HIV Behavioral Surveillance (NHBS) study in NYC. NHBS is a cross-sectional study conducted by the Centers for Disease Control and Prevention (CDC) and local partners on HIV prevalence and risk among MSM, IDU, and high-risk heterosexuals.³⁰ The data are from the high-risk heterosexual cycle conducted in 2006–2007.

The NHBS methods for defining high-risk heterosexuals are explained in detail elsewhere.³¹ Using NYC HIV surveillance data and the United States Census data on household poverty, NYC zip codes were ranked by combined standardized rates of heterosexual HIV and poverty. The top 30 zip codes, which were clustered in Central Brooklyn, Harlem, and the South Bronx, were considered “high-risk areas” (HRAs).

Study participants had to reside in or have a social connection to an HRA. Participants were considered to have a social connection if they were recruited into the study by a previous participant who resided in an HRA. The sample was accrued using respondent-driven sampling (RDS), which is based on peer recruitment.^{32,33} Ethnographers selected initial recruits ($n=8$), called seeds, through the assistance of key informants and community outreach. Seeds met eligibility criteria for the study, were socially gregarious within the local community, and had large social networks. Once the seeds completed the study, they were asked to recruit up to three peers (friends, relatives, or people they were close to, who were between 18 and 50 years of age, who lived in the project area, and who they had seen in the past 30 days). Peers who participated in the study were asked to recruit their peers and so on, until the target sample size was met. Participants who lived outside an HRA were not allowed to recruit others, in order to maintain the connection to HRAs.

Other eligibility criteria included opposite sex vaginal/anal sex in the past year, age between 18 and 50 years, NYC residence, and English/Spanish comprehension. Eligible participants were paid \$20 for completing the questionnaire, \$10 for taking the HIV test, and \$10 for each eligible participant (up to three) they recruited.

After giving their informed consent, participants were administered a computer-assisted structured interview in private by trained interviewers. Interviews were conducted in English or Spanish in study offices located in HRAs in Central Brooklyn and Central Harlem. After the interview was completed, blood specimens were obtained through venipuncture by a trained phlebotomist from participants who consented to be tested. The blood specimens were tested for HIV-1 at the New York City Public Health Laboratory. All procedures involving human subjects were reviewed and approved by the Institutional Review Boards of the New York City Department of Health and Mental Hygiene, the National Development and Research Institutes, and the CDC.

Geographic Coverage and Demographic Characteristics of Seeds

The eight seeds resided in two HRA clusters: one was in Central Brooklyn (three seeds who resided in the same zip code) and the other in Central Harlem (five seeds who resided in the same zip code). In Central Harlem, the seeds included three men and two women who self-identified as being of Black race/ethnicity and ranged in age from 26 to 44 years. In Central Brooklyn, the three seeds were female, self-identified as Black, and ranged in age from 24 to 49 years. From these eight seeds, the study recruited participants who resided in all five boroughs (50.2 % in Brooklyn, 31.1 % in Manhattan, 17.2 % in the Bronx, 1.3 % in Queens, and 0.3 % in Staten Island) and in 74 zip codes.

Measures

In the interview, participants were asked about their sociodemographic characteristics, injection drug use history, noninjection drug use in the past 12 months, alcohol use in the past 30 days, sexual risk behaviors and number of sex partners in the past 12 months, the characteristics of their last sex partner in the past 12 months, e.g., whether the partner was HIV-positive, and recent (past 12 months) diagnoses with STDs.

The variable “any STD diagnoses” was based on the participant's self-report of being diagnosed by a doctor, nurse, or other health care provider with either syphilis, gonorrhea, chlamydia, herpes (HSV), genital warts (HPV), or other STDs. RSPC was measured for the last opposite gender sex partner during the previous 12 months who was not an exchange partner (an exchange partner was defined in the questionnaire as someone with whom the participant had sex in exchange for things like money or drugs). Participants were asked if they had sex with other people during their sexual relationship with this last sex partner. Participants were also asked if this last sex partner had sex with other people during their sexual relationship. The responses of “definitely did” and “probably did” were recoded as “yes”, and the responses “definitely did not” and “probably did not” were recoded as “no”. RSPC was defined as occurring when a participant reported that both the participant and the last sex partner had sex with other people during their sexual relationship in the past 12 months (coded as “yes/no”).

Other variables in the analysis included sociodemographic characteristics (gender, race/ethnicity, age, sexual identity, less than high school graduation or less than a

General Educational Diploma [GED], marital status, and in the past 12 months, an income of less than \$10,000, being homeless, and being arrested), ever (lifetime) injecting drugs, weekly use of noninjection drugs (crack, cocaine, heroin, and marijuana), binge alcohol use (for men, five or more drinks in one “sitting”; for women, four or more drinks in one “sitting”) in the last 30 days, sexual risk in the past 12 months (unprotected vaginal sex, unprotected anal sex, and more than three [the median] sex partners), characteristics of the last sex partner (five or more years older, ever injected drugs, ever used crack, ever incarcerated, HIV-infected or HIV status unknown, and duration of partnership was more than 2 years [the median]), the participant's HIV test result from being tested at the interview, and the size of the participant's personal network.³¹ Personal network size was determined by asking participants how many of their peers, as defined above, they had seen in the last 30 days.

Participants Analyzed

The eight seeds generated 1,015 recruits, of whom 850 were eligible. Of the 850 who were eligible, 133 were excluded from the analysis, including, in hierarchical order of elimination, 105 with last sex partners who were exchange partners, two with missing data for the questions on concurrency in the last sex partnership, four who reported that they were HIV-positive, and 22 men who had sex with men in the last 12 months. Those who self-reported as being HIV-positive were excluded because awareness of HIV status can influence risk behavior.³⁴ The analysis was conducted on 717 participants.

Statistical Analysis

Bivariate analysis was conducted to test (Pearson's Chi-square) for variables that were significantly associated with RSPC. The association of any STD diagnoses with RSPC and the significant correlates of RSPC was determined using bivariate and multivariate logistic regression to estimate crude and adjusted odds ratios (OR and aOR, respectively) and 95 % confidence intervals (95%CI). Race/ethnicity, age, gender, the number of sex partners, the duration of the last sex partnership, and the reciprocal of the participant's reported personal social network size (to control for the probability of being selected for the sample) were forced into the multivariate model as control variables or covariates. A confirmatory multivariate analysis was conducted that included RSPC (the exposure variable), the variables forced into the original multivariate model, and variables (as listed in Table 1) that, when added separately to a model with only the exposure variable, changed the coefficient of the exposure variable by more than 10 %.³⁵

Multicollinearity between the explanatory variables included in the multivariate model was assessed.³⁶ The diagnostic measures of collinearity utilized included Tolerance (TOL), the Variance Inflation Factor (VIF), and the weighted TOL and VIF.

Although RDS data are subject to recruitment biases related to network size and homophily (preferential in-group recruitment),^{33,37} we conducted unweighted analyses because RSPC is a network variable that is structured by network size and homophily.³¹ To assess whether a weighted analysis would influence the estimated effect of RSPC, we conducted a sensitivity analysis for the multivariate model using RDS weights for any STD diagnoses.^{38,39} Analyses were conducted using SAS® v9.1 (SAS Institute, Cary, NC, USA).

TABLE 1 Characteristics associated with reciprocal sex partner concurrency

Characteristics	Total		RSPC	
	<i>N</i>	<i>c%</i>	<i>r%</i>	<i>p</i>
Total	717	100.0	40.7	
Gender				0.13
Male	341	47.6	37.8	
Female	376	52.4	43.4	
Race/ethnicity				0.81
Black	533	74.3	40.3	
Hispanic	130	18.1	43.1	
White	38	5.3	42.1	
Other	16	2.2	31.3	
Age				0.15
18–29	237	33.1	42.2	
30–39	116	16.2	47.4	
40–50	364	50.8	37.6	
Other sociodemographics				
Nonheterosexual identity	104	14.5	61.5	<0.01
Less than high school graduation/GED	305	42.5	44.3	<0.10
Not married or not living as married	635	88.6	41.9	0.08
Income <10,000 (PY)	476	66.4	43.3	<0.06
Homeless (PY)	325	45.3	43.7	<0.15
Arrested (PY)	198	27.6	41.4	0.82
Substance use				
Drug injection (lifetime)	138	19.3	44.9	0.27
Weekly crack use (PY)	140	19.5	50.0	0.01
Weekly cocaine use (PY)	66	9.2	57.6	<0.01
Weekly heroin use (PY)	66	9.2	50.0	0.11
Weekly marijuana use (PY)	250	34.9	49.6	<0.01
Binge alcohol use (PM)	301	42.0	49.8	<0.01
Past year sexual risks				
Unprotected vaginal sex	658	91.8	42.9	<0.01
Unprotected anal sex	240	33.5	53.3	<0.01
>3 total sex partners	325	45.3	63.1	<0.01
Last sex partner characteristics				
≥5 years older	174	24.3	43.7	0.37
IDU	81	11.3	46.9	0.23
Used crack	242	33.8	45.9	<0.05
Ever incarcerated	355	49.5	43.7	<0.12
HIV-positive or status unknown	361	50.4	52.1	<0.01
Partnership >2 years	343	47.8	37.0	0.06
HIV test result				0.78
Negative	644	92.5	41.0	
Positive	52	7.5	40.4	
Not tested	21	2.9	33.3	

c% column percent, *r%* row percent, *PY* past year (12 months), *PM* past month (30 days)

RESULTS

Characteristics of the analysis sample (*N*=717) are shown in Table 1 (*c%* represents the column percentages based on the total sample size denominator). The analysis

sample was 52.4 % female and 47.6 % male. Almost three-quarters self-identified as being of Black race/ethnicity and close to a fifth as Hispanic, with few identifying as White or other race/ethnicity. The mean age was 36.0 years (standard deviation = 10.4 years), with a median age of 40 years (range 18 to 50 years). A minority (14.5 %) reported a nonheterosexual identity (0.8 % homosexual, gay or lesbian, and 13.7 % bisexual). Over 40 % did not graduate high school or receive a GED. A majority (88.6 %) were unmarried or not living as married. Two-thirds reported an annual household income of less than \$10,000. In the past year, many (45.3 %) had ever been homeless and just over a quarter had been arrested. Almost a fifth had ever (lifetime) injected drugs. Noninjection drug use and binge alcohol use were common. Over 90 % engaged in unprotected vaginal sex, a third in unprotected anal sex, and 45.3 % had more than three sex partners. Many reported last sex partners who were potentially high risk, e.g., 50.4 % had a last sex partner with a positive or unknown HIV status. HIV infection prevalence (7.5 % of 696 tested at the interview) was high for this population. The median self-reported personal social network size was ten (range 0 to 1,000).

Variables associated with RSPC are shown in Table 1 (r% represents row percentages based on row sample size denominators). RSPC was reported by 40.7 % of participants, with 36.3 % reporting that one partner had other partners (25.9 % only participants and 10.4 % only sex partners), and 23.0 % that neither partner had other partners. In the bivariate analysis, variables significantly associated with RSPC included nonheterosexual identity ($p < 0.01$), weekly noninjection use of crack ($p = 0.01$), cocaine ($p < 0.01$), and marijuana ($p < 0.01$), binge alcohol use ($p < 0.01$), unprotected vaginal sex ($p < 0.01$), unprotected anal sex ($p < 0.01$), having more than three sexual partners ($p < 0.01$), having a last sex partner who used crack ($p < 0.05$), and a last sex partner whose HIV status was reported as positive or unknown ($p < 0.01$).

Overall, almost one in four (23.4 %) reported that they had been diagnosed with any STDs in the prior 12 months (Table 2). This included 4.3 % reporting syphilis, 8.1 % gonorrhea, 9.4 % chlamydia, 2.1 % herpes, 1.7 % genital warts, and 3.6 % other STDs (not mutually exclusive). In the bivariate analysis, those who reported RSPC compared with those who did not were twice as likely to report being diagnosed with any STDs (31.5 % vs. 17.9 %, OR = 2.11, 95%CI = 1.49–3.00, $p < 0.01$). In additional contrast analyses (data not shown in Table 2), those who reported RSPC were significantly more likely to report any STD diagnoses than were those who reported that neither the participant nor the last sex partner had other sex partners (17.6 %, OR = 2.16, 95%CI = 1.35–3.45, $p < 0.002$), only the participant had other sex partners (19.9 %, OR = 1.85, 95%CI = 1.20–2.87, $p < 0.01$), and only the last sex partner had other sex partners (13.5 %, OR = 2.94, 95%CI = 1.45–6.00, $p < 0.003$). Other significant variables included female gender, unprotected anal sex, and reporting more than three sex partners in the past year.

Having a last sex partner who was an exchange sex partner ($N = 93$) may be a proxy variable for RSPC. “Any STD diagnoses” was reported by 29.0 % of those reporting exchange partners (data not shown in Table 2).

In the multivariate analysis, RSPC (yes vs. no) was independently associated with any STD diagnoses after accounting for the effects of sexual, drug use, and other risk variables (aOR = 1.54, 95%CI = 1.02–2.32, $p < 0.04$). Other significant variables included female gender (aOR = 2.15, 95%CI = 1.43–3.23, $p < 0.01$), engaging in unprotected anal sex (aOR = 1.65, 95%CI = 1.12–2.42, $p < 0.02$), and having more than three sex partners in the past year (aOR = 1.72, 95%CI = 1.13–2.63, $p < 0.02$).

TABLE 2 Bivariate and multiple logistic regression of STD diagnoses

Characteristic	Total	STD		Crude		Adjusted	
	<i>N</i>	<i>n</i>	<i>r</i> %	OR	95 % CI	OR	95 % CI
Total	717	168	23.4	—	—	—	—
Gender							
Male	341	59	17.3	1.00		1.00	
Female	376	109	29.0	1.95	1.36–2.79	2.15	1.43–3.23
Race/ethnicity							
Black	533	127	23.8	1.01	0.47–2.19	1.34	0.59–3.07
Hispanic	130	28	21.5	0.89	0.38–2.08	1.17	0.47–2.93
White	38	9	23.7	1.00		1.00	
Other	16	4	25.0	1.07	0.28–4.17	1.57	0.37–6.60
Age							
18–29	237	58	24.5	1.00		1.00	
30–39	116	28	24.1	0.98	0.56–1.65	0.83	0.46–1.47
40–50	364	82	22.5	0.90	0.61–1.32	0.92	0.57–1.49
Nonheterosexual identity	104	31	29.8	1.48	0.93–2.34	0.84	0.49–1.45
Substance use							
Weekly crack use (PY)	140	39	27.9	1.34	0.88–2.04	0.96	0.57–1.59
Weekly cocaine use (PY)	66	15	22.7	0.96	0.52–1.75	0.74	0.38–1.43
Weekly marijuana use (PY)	250	65	26.0	1.24	0.87–1.78	1.15	0.77–1.71
Binge alcohol use (PM)	301	74	24.6	1.12	0.79–1.58	0.93	0.63–1.37
Past year sexual risks							
Unprotected vaginal sex	658	160	24.3	2.05	0.95–4.41	1.31	0.58–2.93
Unprotected anal sex	240	76	31.7	1.94	1.36–2.77	1.65	1.12–2.42
>3 total sex partners	325	99	30.5	2.05	1.44–2.91	1.72	1.13–2.63
Last sex partner characteristics							
Used crack	242	66	27.3	1.37	0.96–1.96	1.30	0.83–2.03
HIV-positive or status unknown	361	93	25.8	1.30	0.92–1.84	1.07	0.73–1.56
Partnership >2 years	343	82	23.9	1.05	0.75–1.49	1.15	0.79–1.67
Reciprocal sex partner concurrency							
No	425	76	17.9	1.00			
Yes	292	92	31.5	2.11	1.49–3.00	1.54	1.02–2.32

r%, row percent, PY past year (12 months), PM past month (30 days)

Personal social network size was not significant (aOR=1.92, 95%CI=0.74–5.00, $p<0.18$). To account for high outliers in personal social network size, the natural log of personal social network size was included as a control variable. The final model was essentially unchanged when this variable was included.

In the confirmatory analysis, only having more than three sex partners in the past year changed the coefficient of RSPC by more than 10 %. The effect of RSPC was similar in this reduced multivariate model (aOR=1.65, 95%CI=1.12–2.44, $p<0.02$).

None of the measures for assessing multicollinearity indicated that the explanatory variables in the multivariate model were collinear. The lowest TOL was 0.70 and the highest VIF, 1.43, which was also confirmed by the weighted assessment.

With the exception of personal social network size, all of the variables included in the original unweighted multivariate analysis were included in the RDS weighted multivariate analysis. The effect of RSPC on any STD diagnoses was similar in the weighted analysis, although statistical significance became marginal (aOR=1.85, 95%CI=0.98–3.49, $p<0.06$).

DISCUSSION

Among heterosexuals who lived in or were socially connected to high HIV-risk areas in NYC, the prevalence of RSPC was high and almost a quarter had been diagnosed with STDs in the past year. Any STD diagnoses was associated with RSPC but not with mono concurrency (for either the participant or the participant's last sex partner). Those who reported RSPC during their last sexual relationship were twice as likely to report being diagnosed with STDs as those who did not. When we accounted for potential confounders, RSPC remained independently associated with any STD diagnoses.

Although sex partner concurrency is a plausible theory to explain the extent, rapidity, and persistence of heterosexual STD and HIV epidemics, questions remain over whether it is empirically supported. A possible source for inconsistent findings is that sex partner concurrency is often defined and operationalized as an indicator of individual risk rather than of network or population risk.⁴⁰ In our analysis, sex partner concurrency was specified to apply not only to participants but also to participants' sex partners. Inconsistent findings on the relationship of sex partner concurrency to infection with HIV and other STDs may result from undifferentiated measures of sex partner concurrency, since some with concurrent sex partners may not have sex partners who have other sex partners, who may be more likely to be transmitters of HIV and other STDs. In studies of STD transmission in the United States, Koumans et al.⁴¹ and Potterat et al.⁴² found that those with concurrent partners were more likely to be STD transmitters. Among STD clinic attendees in St. Petersburg, Russia partner concurrency but not individual concurrency was significantly associated with diagnosed STDs.⁴³ Moreover, Adimora and et al.,¹⁰ in a study of heterosexually transmitted HIV among African Americans in North Carolina, found that the risk for infection with HIV among those who denied high-risk behaviors or partners was independently associated with having a sex partner who was not monogamous during the relationship with the participant. However, these studies did not specifically analyze the combined effect of both individual and partner concurrency (RSPC). In our study, we found that RSPC was associated with a greater risk of having diagnosed STDs not only compared with neither the participant nor the partner having other sex partners but also with only participant concurrency and only partner concurrency.

Other variables independently associated with any STD diagnoses included unprotected anal sex and female gender. In a previous analysis of these data, we found that unprotected anal sex was an independent predictor of any STD diagnoses among women.³⁸ The association of unprotected anal sex with STD diagnoses persisted in this larger sample of men and women. There is increasing evidence that the prevalence of anal sex is considerable in some high-risk heterosexual populations^{44–46} and may place women engaging in this sexual practice at high-risk for infection with HIV and other STDs.^{38,47} The higher risk of STD diagnoses among women is consistent with other research which finds that women are more susceptible to becoming infected with some STDs.^{48,49} Women may also be more likely to be screened for STDs, which may increase their likelihood of being diagnosed.⁴⁹

RSPC, independent of the number of sex partners and individual sexual risk behaviors, may generate heterosexual HIV epidemics in HRAs at both the individual and population levels by increasing the individual risk of acquiring or transmitting STD cofactors and HIV and, at the population level, by increasing the prevalence of STDs and HIV and their spread through larger and longer sexual transmission

networks. Interventions that target high-risk urban areas, such as those in NYC, could help to reduce the incidence of HIV and other STDs by promoting the reduction of sex partner concurrency through direct messages emphasizing “one partner at one time”¹² as well as by addressing individual risk factors, such as stimulant drug use and binge alcohol use, or structural risk factors, such as high rates of unemployment and incarceration,⁵⁰ which may generate sex partner concurrency. Such interventions could create a multiplier effect in which the reduction of RSPC could add value at the population level to existing individual-level interventions and increase efficiency in the use of scarce prevention resources.

LIMITATIONS

Some participants may have been misclassified if they did not report RSPC at the last sex partnership but RSPC occurred in prior sex partnerships in the last 12 months. In addition, the identification of whether the last sex partner had other sex partners is based on self-report, which may be inaccurate if the last sex partner did not disclose or the participant did not suspect other sex partnerships.⁵¹ Since the measure of sex partner concurrency was a direct measure and not based on the specific timing of partnerships,⁵² some participants may have misreported closely spaced sequential partnerships as concurrent partnerships. Those with asymptomatic STDs, particularly gonorrhea and chlamydia, would have been less likely to report being diagnosed with STDs. Even with these sources of potential misclassification and conservative bias, RSPC was found to be associated with being diagnosed with STDs. The summary measure of diagnosed STDs used in the analysis may not reflect heterogeneity in how different STDs are distributed in sexual networks and geographically,^{53–55} although focusing RDS in HRAs may have increased the overlap between the sexual networks and geographic concentration of different STDs.⁵⁶ The inference of a causal relationship between RSPC and STDs is limited by the cross-sectional design of the study and differences in the time frames used to measure RSPC and STD diagnoses. The sample was not randomly selected and caution is thereby necessary in generalizing the results to heterosexuals living in or socially connected to the HRAs in the sample. Additionally, because the HIV epidemic in the United States overall is concentrated while in some African countries it is generalized, caution is also necessary in transferring inferences between the two contexts. However, HIV prevalence in NYC HRAs and in similar urban areas in the United States may be generalized within these areas and is comparable to that found in some generalized heterosexual epidemics in Africa.^{9,57}

CONCLUSIONS

In order to determine the effect of sex partner concurrency on the risk of acquiring or transmitting heterosexually transmitted HIV and other STDs, greater theoretical specificity is needed in measuring sex partner concurrency so that it reflects the dynamics of underlying sexual transmission networks. One such measure, RSPC, can be developed using egocentric sexual network data reported by participants in standard surveys, such as the NHBS survey.

Heterosexuals in high-HIV-risk neighborhoods in sexual partnerships that involve RSPC are at greater risk of STDs and, potentially, HIV. RSPC, in addition to sexual risk behaviors and the number of sex partners, may facilitate the heterosexual spread of HIV through STD cofactors and linkage into larger STD/HIV sexual transmission networks.

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