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Social place as a location of potential core transmitters - Implications for the targeted control of sexually transmitted disease transmission in urban areas

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Abstract

Purpose—Places are an important determinant of risk for sexually transmitted infection (STI) acquisition and transmission. We sought to identify social places that are critical for targeted STI control activities. The objective of this study was to determine whether sex partner meeting places characterized by drug markets, sex markets and separately, drug and/or sex markets were more likely to have potential core transmitters as compared to other sex partner meeting places in one urban setting.

Methods—In 2008–2009, heterosexual sex partner places or venues were identified in Baltimore, MD using a venue-based study approach.

Results—1,334 participants aged 18–35 years were enrolled at 85 venues. 39 potential core transmitters were identified and 31% of venues had at least one potential core transmitter. In final age- and gender-adjusted models, core transmitters were significantly more likely to be identified at drug markets (OR 1.37; 95% CI 1.23, 1.53), sex markets (OR 1.27; 95% CI 1.14, 1.41) and drug and/or sex markets (OR 1.49; 95% CI 1.32, 1.68).

Conclusions—This study identified key characteristics of venues, such as drug and sex market activity, that may be important in identifying places for the targeted control of STI transmission.

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Keywords

sexually transmitted disease; epidemiology; heterosexuality; social environment

INTRODUCTION

A body of work in the field of sexually transmitted infections (STIs) supports the role of environment as a driver of STI transmission risk with some arguing that the risk environment is the most important determinant of STI acquisition and transmission (1–5). The risk environment is defined as the social and physical space in which factors exogenous to the individual interact to increase infection risk for an individual. The risk environment may include, for example, social venues such as bars, clubs and street corners (1, 6). These social venues may be an important source of risk for STIs in three ways - by attracting individuals who practice STI-related risk behaviors (e.g., inconsistent condom use), encouraging or enabling individual risk-related behaviors (e.g., having multiple sex partners), and/or by creating the opportunity for high risk individuals to coalesce into risk-related sexual networks with specific structural characteristics (e.g., cohesiveness, concurrency).

There has been direct and indirect evidence supporting the importance of social venues and their characteristics for STI transmission risk. Seminal work in this area by Potterat, et al. (1985) in Colorado Springs demonstrated, for example, that gonorrhea occurs in small, socially definable segments of the population and that the individuals in the segments showed significant social association via nighttime social venues (1). Another study by Potterat, et al. (1999) in a comparison between two distinct networks of individuals at risk for STIs and HIV suggested that transmission was associated with structural characteristics of networks (i.e. network cohesion) (7). In a multilevel cross-sectional household study among youth in an urban setting, Jennings, et al. (2012) demonstrated that neighborhood drug market venues (specific venues where illicit drug dealing occurs) were associated with an increased likelihood of selecting a high-risk sexual partner and, separately, of current infection with a bacterial STI (4, 5). These latter results support the hypothesis that specific social venues, i.e. neighborhood drug market venues, have the necessary and sufficient factors to maintain disease transmission, namely disease prevalence and highly interconnected network structures. Drug market venues with their economies of drug trade and often co-occurring economies of sex work are likely places with highly interconnected network structures, which potentiate STI transmission (7). This premise is further supported by other work that has found drug dealers and users have high STI prevalence (8, 9).

In the current study, we extend this work to look directly at individuals congregating at venues to determine whether drug and/or sex market venues are more likely to be frequented by individuals most likely to transmit STIs, i.e., core transmitters, than other venues. Core transmitters are defined here by their sexual network connectivity and disease status, i.e. self-report of sexual concurrency and diagnosis of a current bacterial STI (10). To the extent that we can establish a direct link between these venues and transmission risk, these venues may be effective targets for structural and individual level STI control activities.

The objective of this study was to determine whether sex partner meeting places characterized as drug markets, sex markets and separately, drug and/or sex markets were more likely to have potential core transmitters as compared to other sex partner meeting places in one urban setting. We tested the independent association each type of market in an attempt to tease out the importance of each as well as the potential interaction of the two types of venues.

METHODS

Study Setting

Host to longstanding syndemics of poverty, illicit drug use and STIs, Baltimore is located in the Mid-Atlantic United States (U.S.) with an estimated 2010 population of 619,493 people (11). Baltimore is the sixth poorest metropolitan area in the U.S. with a poverty rate of 24%, nearly double the national rate (12). Baltimore has high rates of injection drug use (IDU) and non-injection drug use (13–15). Roughly 10% of Baltimore's population, 60,000 people, have been estimated to be illicit drug addicts (16, 17). Baltimore has endemic rates of STIs as well as racial/ethnic disparities in STIs that are two to four times the national average (18). In 2011, Baltimore had the sixth highest chlamydia and tenth highest gonorrhea incidence among U.S. counties and independent cities (18). The Baltimore-Towson metropolitan area had the sixth highest HIV incidence of any U.S. metropolitan area (19).

Study Design

The study design was a venue-based, cross-sectional study of adults, 18 to 35 years of age, conducted in Baltimore, Maryland from October 2008 through December 2009. Potential high STI-risk sex partner meeting venues were identified using a three-phase, venue-based methodology described previously (20, 21) and based on the Priorities for Local AIDS Control Efforts (PLACE) methodology (22). Briefly, in phase one, multiple sources of information were used to identify specific sex partner meeting venues and high STI-risk areas (i.e., census block groups [CBGs]) where sex partner meeting venues might exist). In phase two, brief windshield tours were conducted in order to identify venues where people congregated. In phase three, observational data were collected and venue informant interviews were conducted to identify high volume, heterosexual sex partner meeting venues.

Venue Selection

In phase one, information about potential heterosexual sex partner meeting venues was obtained from three sources: 1) sex partner meeting places reported by syphilis and HIV infected individuals (n=309) as a part of routine partner services interviews from 2003–2004 and 2006; 2) interviews with 26 key informants likely to be knowledgeable about sex partner meeting places, and 3) a 2006 on-line directory of strip clubs to generate a list of potential venues. We also utilized public health surveillance data and other administrative data sets to identify high-STI-risk CBGs with: 1) high (>92nd percentile) gonorrhea rates from 2002–2004 (n=30); 2) high (>95th percentile) violent crime counts and high (>97.5th percentile) property crime counts from 2004–2005 (n=10); 3) high drug prevalence (n=10) (defined as top ten factor scores based on a factor analysis of average count of narcotics-

related 911 calls from 1998–2001 and average count of juvenile drug arrests from 1998–2003); and 4) high (95th percentile) heroin-related overdose fatality counts (n=7) from 2004–2006. De-duplication of 77 CBGs yielded 68 unique CBGs, representing 9.6% (68/710) of CBGs in Baltimore.

In phase two, three brief windshield tours of each venue and high-STI-risk area were conducted, one each in the morning, afternoon and evening (23). A brief windshield tour consisted of a three-hour driving tour in order to record the locations and times of gatherings of three or more potential age-eligibles exclusive of bus stops, bars, and package stores. Bars and package stores were excluded under the assumption that high profile bars were captured by phase one key informant interviews and the inclusion of strip clubs. A venue was included in phase three if people were observed to congregate there on more than one occasion.

In phase three, staff administered venue informant interviews to three patrons, passers-by, or business owners at each venue while again assessing the number of people congregating and/or passing by. Based on these data, venues were excluded if 1) all venue informants said no people met sex partners there; or 2) no venue informant said sex partners met there, the interviewer observed less than three people and all venue informants reported less than six people gathered at the venue at any time; or 3) staff reported the venue to be predominantly a meeting place for men who have sex with men (MSM). A venue was included if one or more venue informants reported it to be a sex partner meeting place or it was selected as part of a 66% random sample. The random sample was selected from among venues meeting neither exclusion nor inclusion criteria, i.e. venues where venue informants answered “don’t know” or “no” as to whether people met sex partners there and either: 1) greater than three people were observed by the interviewer; or 2) three venue informants reported at least six people would gather there at any time. All venues at which participants were later recruited met these venue selection criteria regardless of the original method used to identify the venue. Venues included nightclubs, bars, street corners, parks, high schools and a college.

Participant Recruitment and Interview Procedures

Operating from a modified recreational vehicle, a team of three staff members recruited and enrolled participants at the selected venues between 6 p.m. and 9 p.m. on consecutive nights until 20 participants had been recruited per venue. Staff approached anyone who stepped into the area of sidewalk adjacent to the van. Eligibility criteria included 18 to 35 years of age, English-speaking, and sexually active within the last three months. Eligible and interested participants provided informed consent and completed a brief, staff-administered questionnaire. Biologic samples including urine samples from males and self-administered vaginal swabs from females were collected from participants for gonorrhea and chlamydia testing using an FDA-licensed nucleic acid amplification test (ProbeTec). Participants received \$20 as remuneration.

STI positive participants were notified of their results and referred for care. STI positives were also reported to the health department for reporting purposes. The Johns Hopkins School of Medicine Institutional Review Board approved this study.

Participant Measures

Potential core transmitter status (outcome): Based on prior direct empiric evidence (10), an individual was defined as a potential core transmitter if they self-reported sexual concurrency and tested positive for a bacterial STI infection (gonorrhea and/or chlamydia). Sexual concurrency was defined as a report of yes to either of the two following questions: “In the last six months, have you had more than one sex partner within the same week?” and “In the last three months, have you had at least one other partner during the time you were seeing your main partner?”

Demographics: Age, gender (male, female) and race/ethnicity (Black, White, Asian, Hispanic or Other) were self-reported by the participant. Race/ethnicity was recoded to Black, White and Other. Educational attainment (less than high school, some high school, high school or general equivalency diploma (GED), some college, bachelor’s degree, and graduate studies) was self-reported as the highest level of schooling completed and recoded to less than or greater than a high school education/GED. Residential location of the participant and their most recent sex partner as within or beyond the neighborhood of the venue at which they were recruited were also self-reported.

Sexual risk factors: Number of sex partners in the past 6 months, sex without a condom in the last 6 months (yes, no), sex with an anonymous partner in the past 12 months (yes, no), history of gonorrhea or chlamydia infection (yes, no), sex partner IDU (yes, no) and sexual exchange in the past 12 months, i.e. traded drugs for sex or sex for drugs (yes, no).

Drug-related risk factors: Ever bought or sold drugs (yes, no), crack cocaine use in the past 12 months (yes, no), ever IDU (yes, no), and IDU (yes, no) and needle sharing in the past 6 months (yes, no).

Venue Characterization

Drug market venue: A venue was classified as a drug market if any venue informant reported venue-based drug selling in response to either of the following two questions: (i) “Why do people come here? (to meet new people, to see people they already know, to buy or sell drugs or don’t know)”;

Sex market venue: A venue was classified as a sex market if any venue informant interviewed in phase three answered yes to the question, “Do women here have sex in exchange for money or drugs?”

Drug and/or Sex market venue: A venue was classified as a drug and/or sex market if the venue was classified as a drug or sex market venue.

Statistical Analysis

Bivariate associations between potential core transmitter status and participant characteristics including demographics and sexual and drug-related risk factors were determined using a t-test, chi-square or Fisher’s exact test, as appropriate. Similarly, bivariate associations between potential core transmitter status and venue-level

characteristics including drug market, sex market and drug and/or sex partner venue status were determined.

Next, we conducted a series of unadjusted and adjusted multi-level random-effects logistic regression models with an exchangeable correlation structure. Multilevel modeling was used as the primary analytical technique to account for the nested data structure, i.e. participants (level 1) nested within venues (level 2). Multilevel analysis accounts for the non-independence of observations within groups, uses empiric Bayes adjustments for the group means, and allows for the statistical testing of the between-and within-group variances on the outcome variables (24, 25). Adjusted regression models controlled for age and gender because our hypothesis was that the likelihood of core transmitter status and individual level risk would increase with age and that sexual risk behavior and roles within a market may differ according to gender. In another series of models, we conducted sensitivity analyses where we additionally controlled for significant individual-level characteristics. All statistical procedures were performed using a hierarchical linear and nonlinear modeling program (HLM version 6.02, Scientific Software International, Inc., Skokie, IL).

RESULTS

We screened 2,247 potential participants and 24% (545) were either screened ineligible (n=510) or screened eligible but refused (n=35). We enrolled 1,702 participants from 87 venues. Five percent (89) of participants were excluded due to missing interview data. We excluded an additional 14% (244) because they did *not* self-report their sexual preference to be either straight or heterosexual and/or they were missing STI testing results. Additionally 2% (35) were excluded because two venues lacked venue informant interviews and thus, did not have venue-level information. The final study population was 1,334 participants from 85 venues.

Three percent (39) of participants were classified as potential core transmitters (defined as currently STI infected and self-reporting sexual concurrency) including 3.0% (19) of males and 2.9% (20) of females (Figure 1).

The mean age of study participants was 27.5 (SD 6.1) years; approximately half of participants were male (48%) (Table 1). The majority of participants were Black (85%), 41% had earned less than a high school diploma or GED and 67% reported that they lived in the local neighborhood. Additional STI history and sexual risk and drug-related behaviors are presented in Table 1. Potential core transmitters compared to non-core transmitters were significantly different on a number of demographic and sexual risk and drug-related behaviors (Table 1).

At the venue level, 31% (26/85) of venues had at least one potential core transmitter. Fifty-three percent (45) of venues were classified as drug markets, 40% (34) of venues were classified as sex markets and 62% (53) of venues were classified as drug and/or sex markets. Among venues with at least one (versus no) core transmitter/s, 58% (15/26) vs. 51% (30/59) were drug markets, 46% (12/26) vs. 37% (22/59) were sex markets, and 69% (18/26) vs. 59% (35/59) were drug and/or sex markets.

In unadjusted bivariate analyses, potential core transmitters were significantly more likely to be identified at drug markets (odds ratio [OR] 1.34; 95% confidence interval [CI] 1.20, 1.50), sex markets (OR 1.20; 95% CI 1.08, 1.34), and drug and/or sex markets (OR 1.43; 95% CI 1.27, 1.61) as compared to other venues (Table 2). In analyses adjusted for age and gender, potential core transmitters were significantly more likely to be identified at drug markets (adjusted OR 1.37; 95% CI 1.23, 1.53), sex markets (adjusted OR 1.27; 95% CI 1.14, 1.41) and drug and/or sex markets (adjusted OR 1.49; 95% CI 1.32, 1.68) as compared to other venues.

To determine whether venue level factors were independently associated with potential core transmitter status and were not just indicators of individual level behaviors, we conducted a sensitivity analysis to determine whether the drug and sex market associations persisted after controlling for individual factors significantly associated with core transmitter status. These results were similar to findings without adjustment for individual sexual risk and drug-related behaviors except potential core transmitters were not significantly more likely to be identified at sex markets as compared to other venues (Table 3)

DISCUSSION

Reducing rates of bacterial STIs such as gonorrhea and chlamydia is a national priority. A mainstay of STI prevention and control consists of targeting for treatment those individuals who are likely to transmit infection to the largest number of people, i.e. core transmitters (26–30). In this venue-based study in one urban setting, our overall goal was to identify venues or places with core transmitters, which may serve as foci for ongoing STI transmission and may be ideal sites for the targeted control of STIs (31, 32). A strength of the study is our use of rich, on-the-ground data to improve the classification of venues beyond what can be gleaned from other administrative data sets such as census data similar to work by Wohl DA, et al. (2011). Our results support the idea that drug and/or sex market venues are more likely to be frequented by individuals most likely to transmit STIs, i.e., core transmitters, than other venues and that risk environments may drive STI transmission risk. In this study, 62% of venues were classified as drug markets, sex markets and drug and/or sex markets and potential core transmitters were significantly more likely to be identified at these venues. The findings are similar to work by Tobin KE, et al. (2012) which found evidence of spatial clustering of sex exchange and in particular in one housing complex in East Baltimore among a sample of predominantly injection drug users (33).

We speculate that drug and sex venues perpetuate and/or create risk through the creation of highly interconnected sexual network structures consisting of individuals engaged in drug and sex market activity (4, 5, 7, 34). Ongoing STI transmission requires that infected persons frequently come into contact with susceptible persons. The drug market activity and sex work result in short-term multiple sex partnerships that create overlapping sex partnerships at the network level, i.e., concurrency (35–39). Concurrency creates the opportunity for contact between infecteds and susceptibles and the on-going transmission.

Our findings have two important implications. First, testing and treatment at drug and sex market venues should be a priority for STI prevention and control programs. Second, it is

essential to disrupt drug and sex market risk environments that underpin high transmission network structures in order to reduce ongoing transmission of STIs that maintain endemic bacterial STI rates in communities with these venues.

There are several limitations to this study. The cross-sectional design precludes drawing conclusions about causation. Self-reported data on demographic and sexual risk and drug-related behaviors may have been misreported due to social-desirability or poor recall. The association between individual-level behaviors and core transmitter status may have been underestimated due to the focus on recent participant risk behaviors, i.e. in the past 6–12 months. Misclassification of venues may have distorted associations between venue-level drug exposure and core transmitters. Finally, the results may be generalizable to similar U.S. cities, i.e. those with mature epidemics of STIs and histories of drug markets, but not to all U.S. cities. These limitations should be addressed in future studies of this important topic.

This work joins a broader movement within the social sciences, which has become more sensitized to the importance of place in shaping human behaviors and networks (40, 41). It also joins recent work in translational science, which seeks to improve our understanding of STI transmission dynamics and translate these findings into specific recommendations for the targeted control of STIs (33, 42). Future research should focus on providing a better understanding of the stability of the identified venues and identifying other important features of venues which distinguish places with ongoing transmission. Future research should also test methods to disrupt the networks and the transmission within the networks, investigate the relative cost benefit of place-based testing and treatment and explore community receptivity to place-based testing and treatment.

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Acronyms and Abbreviations

CBGs	Census Block Groups
CI	Confidence Interval
FDA	Food and Drug administration
GED	General Equivalency Diploma
HIV	Human Immunodeficiency Virus
IDU	Injection Drug Use
OR	Odds Ratio
STI	Sexually Transmitted Infection

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Males Only (N=638)

Females Only (N=696)

*Concurrency 1 = more than one sex partner within the same week in the past 6 months

**Concurrency 2 = at least one other sex partner during the time while seeing a main sex partner

Figure 1.

Identification of potential core transmitters using a venue-based approach among heterosexual adults (18–35 years) participating in a venue-based study, Baltimore, MD 2008–2009 (n=1,334).

Table 1

Comparison of socio-demographic characteristics, sexually transmitted infection (STI) history, and sexual risk behaviors by core transmitter status^a among heterosexual adults (18–35 years) participating in a venue-based study, Baltimore, MD 2008–2009 (n=1,334).

Individual-level	Overall	Core transmitter n=39	Non-core transmitter n=1295	P value
Socio-demographics	<i>mean (SD)</i>	<i>mean (SD)</i>	<i>mean (SD)</i>	
Age, years	27.5 (6.1)	25.4 (6.3)	27.5 (6.1)	0.03
	% (n)	% (n)	% (n)	
Gender, male	48 (638)	49 (19)	48 (619)	0.91
Race/Ethnicity				
White	14 (186)	15 (6)	14 (180)	0.79
Black	85 (1102)	85 (33)	85 (1069)	
Other	1 (14)	0	1 (14)	
Education, less than high school education	41 (548)	54 (21)	41 (527)	0.10
Residential location				
Participant lives in this neighborhood	67 (886)	82 (32)	66 (854)	0.04
Sex partner lives in this neighborhood	51 (663)	59 (23)	51 (640)	0.30
STI history				
History of gonorrhea and/or chlamydia	28 (375)	34 (13)	28 (362)	0.42
Sexual risk behaviors				
Sex without a condom in past 6 mos.	71 (942)	77 (30)	70 (912)	0.38
	% (n)	% (n)	% (n)	
> 2 sex partners in the past 6 mos.	25 (332)	64 (25)	24 (307)	<.0001
Sex with an anonymous partner in past 12 mos.	11 (150)	33 (13)	11 (137)	<.0001
Sex partner injection drug use in the past 12 mos.	5 (70)	3 (1)	5 (69)	0.72
Sex/drug exchange in the past 12 mos. ^b	15 (198)	36 (14)	14 (184)	0.0002
Drug-related behaviors				
Crack cocaine use in the past 12 mos.	9 (117)	21 (8)	8 (109)	0.02
Injection drug use in the past 6 mos.	8 (109)	8 (3)	8 (106)	1.0
Needle sharing in past 6 mos.	3 (42)	3 (1)	3 (41)	1.0
Bought or sold drugs (ever)	48 (646)	67 (26)	48 (620)	0.02

^aCore transmitter defined as participant reported concurrent sexual partners and were diagnosed with a current gonorrhea and/or chlamydia infection

^bSex/drug exchange defined as self-report of trade drugs for sex or traded sex for drugs in the past 12 months

Table 2

The adjusted and unadjusted odds ratios (ORs) of identifying a core transmitter^a based on venue-level factors including drug^b, sex^c and drug and/or sex market venues factors among heterosexual adults (18–35 years) participating in a venue-based study, Baltimore, MD 2008–2009 (n=1,334).

Venue-level	Unadjusted OR	Adjusted ORs	Unadjusted OR	Adjusted ORs	Unadjusted OR	Adjusted ORs
Drug Market ^b	1.34 (1.20,1.50)	1.37 (1.23,1.53)				
Sex Market ^c			1.20 (1.08,1.34)	1.27 (1.14,1.41)		
Drug and/or Sex Market					1.43 (1.27,1.61)	1.49(1.32,1.68)
Individual-level						
Age		0.94 (0.93,0.95)		0.94 (0.93,0.95)		0.94 (0.93,0.95)
Gender, male		1.07 (0.96,1.20)		1.06 (0.96,1.19)		1.06 (0.95,1.18)

^a Core transmitter defined as participant reported concurrent sexual partners and were diagnosed with a current gonorrhea and/or chlamydia infection

^b A venue was classified as a drug market if any key informant reported venue-based drug selling.

^c A venue was classified as a sex market if any venue key informant responded yes to the question, “Do women here have sex in exchange for money or drugs?”

Table 3

Sensitivity analyses showing the adjusted odds ratios (ORs) of identifying a core transmitter^a based on venue-level factors including drug^b, sex^c and drug and/or sex market venues factors controlling for significant individual level factors including age and gender among heterosexual adults (18–35 years) participating in a venue-based study, Baltimore, MD 2008–2009 (n=1,334).

Venue-level	Adjusted ORs ^e	Adjusted ORs ^e	Adjusted ORs ^e
Drug Market ^b	1.22 (1.09,1.37)		
Sex Market ^c		1.02 (0.92,1.15)	
Drug and/or Sex Market			1.28 (1.13,1.45)
Individual-level			
> 2 sex partners in the past 6 mos.	4.19 (3.69,4.77)	4.21 (3.71,4.79)	4.21 (3.71,4.79)
Sex with an anonymous partner in past 12 mos.	2.29 (2.01,2.62)	2.27 (1.99,2.60)	2.28 (1.99,2.60)
Sex/drug exchange in the past 12 mos. ^d	1.48 (1.27,1.72)	1.51 (1.30,1.75)	1.48 (1.27,1.72)
Crack cocaine use in the past 12 mos.	1.95 (1.63,2.34)	1.90 (1.59,2.28)	1.94 (1.62,2.33)
Bought or sold drugs (ever)	1.67 (1.45,1.92)	1.68 (1.46,1.94)	1.64 (1.43,1.89)

^a Core transmitter defined as participant reported concurrent sexual partners and were diagnosed with a current gonorrhea and/or chlamydia infection

^b A venue was classified as a drug market if any key informant reported venue-based drug selling.

^c A venue was classified as a sex market if any venue key informant responded yes to the question, “Do women here have sex in exchange for money or drugs

^d Sex/drug exchange defined as self-report of trade drugs for sex or traded sex for drugs in the past 12 mos.

^e All models were adjusted for age and gender.