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Structural bridging network position is associated with HIV status in a younger Black men who have sex with men epidemic

Nirav S. Shah[1], **James Iveniuk**[2], **Stephen Q. Muth**[3], **Stuart Michaels**[4], **Jo-Anne Jose**[5], **Edward O. Laumann**[2,4], and **John A. Schneider**[1,6]

[1]Department of Medicine, University of Chicago

[2]Department of Sociology, University of Chicago

[3]Quintus-ential Solutions, Colorado Springs

[4]National Opinion Research Center, Chicago

[5]Chicago Medical School, Chicago

[6]Department of Health Studies, University of Chicago

Abstract

Younger Black men who have sex with men (BMSM) ages 16–29 have the highest rates of HIV in the United States. Despite increased attention to social and sexual networks as a framework for biomedical intervention, the role of measured network positions, such as bridging and their relationship to HIV risk has received limited attention. A network sample (N=620) of BMSM respondents (n=154) and their MSM and transgendered person network members (n=466) was generated through respondent driven sampling of BMSM and elicitation of their personal networks. Bridging status of each network member was determined by a constraint measure and was used to assess the relationship between this bridging and unprotected anal intercourse (UAI), sex-drug use (SDU), group sex (GS) and HIV status within the network in South Chicago. Low, moderate and high bridging was observed in 411 (66.8%), 81 (13.2%) and 123 (20.0%) of the network. In addition to age and having sex with men only, moderate and high levels of bridging were associated with HIV status (AOR 3.19; 95% CI 1.58–6.45 and AOR 3.83; 95% CI 1.23–11.95, respectively). Risk behaviors observed including UAS, GS, and SDU were not associated with HIV status, however, they clustered together in their associations with one another. Bridging network position but not risk behavior was associated with HIV status in this network sample of younger BMSM. Socio-structural features such as position within the network may be important when implementing effective HIV prevention interventions in younger BMSM populations.

Keywords

Black MSM; HIV; network analysis; bridge; risk behavior

Introduction

Black men who have sex with men (BMSM) in the United States are disproportionally at risk for HIV. Nationwide, it is estimated that 1 in 16 BMSM will be diagnosed with HIV during their lifetime (1), In Chicago, 7 times as many BMSM are infected with HIV

Corresponding Author: John Schneider MD, MPH, Assistant Professor of Medicine and Epidemiology, Departments of Medicine and Health Studies, 5841 South Maryland Avenue, MC 5065, Chicago, IL 60637, 773-702-8349, 773-702-8998, Jschnei1@medicine.bsd.uchicago.edu.

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infection as white MSM with similar sex and drug use behaviors (2). Although the precise mechanisms underlying the disparities in HIV infection among BMSM are unknown, research has suggested that BMSM experience a constellation of risk factors that increase vulnerability to infection, including higher rates of undiagnosed HIV (3), less knowledge of partner's HIV status (4), higher levels of stigma, discrimination and minority stress experiences (5), higher underlying rates of HIV among BMSM (6), and structural factors such as poverty (7).

In addition to these factors, a growing body of research has focused on the role of networks in facilitating HIV transmission among BMSM (8–11). To date, much of this research has examined the extent to which risk is distributed and transmitted through the sexual networks of BMSM (12–15). This work has provided some explanation for high STI rates within and among different racial groups and includes the mixing between high-risk core and low-risk periphery groups, also known as disassortative mixing (16). While mixing within sex networks is likely a major factor in HIV transmission dynamics, networks of Black MSM include non-sexual ties to others that may also exert influence on more proximal factors of HIV transmission, such as high-risk behavior, including group sex, unprotected anal intercourse and using drugs during sex. Thus other (non-sexual) social network structures may explain some of the factors related to HIV risk (17–19), or perhaps to how HIV infected BMSM are organized. These social networks operate through influence and social norms that may be related to risk reduction (20).

While these social norms and influence have been the focus of much attention in the behavioral sciences, the quantifiable structural position of where someone is located within the network (e.g., a bridge(21)) and how this is related to high-risk behavior and HIV transmission has received little attention. Most characterizations of structural positions, such as bridging, have relied on general approximations based upon individual demographic or behavioral characteristics and have been mostly explored in "risk networks". For example a truck-driver status has been equated with a bridging person; an occupation that is associated with spreading HIV from sex worker to wife (22). Linking demographic and behavioral characteristics to social network structural positions is complicated and can lead to misclassification (23). Quantitatively derived network positions, however, have been effectively utilized for detection of contagious outbreaks such as influenza (24) and are likely important for explaining behavior related to transmission patterns of other infectious diseases such as HIV. Accurate quantification of social network structure that leads to bridge characterization (See network graph below), could both help explain current HIV related racial disparities and illuminate points for network-based intervention to prevent onward transmission. Importantly bridges are increasingly recognized not for their transmission potential – "risk networks", but for their unique position and the social capital that they possess (25). Characterization of bridges, including real-time network assessment critical to intervention implementation, is becoming increasingly feasible with readily available digital communication network type data such as email, cell-phones and Facebook (26, 27).

In this network analysis, we generate a single inter-connected network of high-risk younger Black MSM and transgender persons, and evaluate the potential bridging position of network members and how they might be associated with risk behavior and HIV status.

METHODS

Setting

Between January and June of 2010, BMSM were recruited from the South Side of Chicago using respondent-driven sampling (RDS) (28). The South Side of Chicago and adjacent

South suburbs, a 128 square mile region including 34 of the city's 77 community areas and 8 south corridor suburbs, is one of the largest contiguous Black urban community in the United States (72% of 1034K people).(29) All interviews took place at a partnering community-based organization on the South Side by University of Chicago Survey Lab trained community members. All study procedures were approved by appropriate institutional review boards. Informed consent was obtained from all study respondents and waived for network members listed by respondents.

Study Participants

Eligibility Criteria—Study *participants* include both study *respondents* who were interviewed, and the network members (also described as alters by the social network analysis community) about whom they reported. Study respondents were eligible to participate if they 1) self-identified as African American or Black, 2) identified as biologically male, 3) were age 18 years or older, 4) reported anal intercourse with a man within the past 12 months, and 5) were willing and able to provide informed consent at the time of the study visit.

Recruitment

Seeds were selected from two venues on the South Side of Chicago either through referral from HIV program personnel (e.g., case manager) or HIV prevention program staff. In the case of referral, requests for popular or charismatic candidates were made to maximize first wave recruitment (28). Specifically, twelve seeds were recruited using these two approaches: 1) Four seeds were recruited from a local Federally Qualified Health Center that provides HIV primary care; and 2) Eight seeds were referred from existing group Effective Behavioral Intervention prevention programs (30). Each seed was given four vouchers and asked to refer up to four MSM from their social networks, with each subsequent recruit doing the same. In order to deter duplicate enrollment, bilateral arm and wrist measurements were conducted on all respondents (31). All respondents were paid $50 for participation.

Survey Instruments

Social Network Assessment—In designing our network instrument, we followed an established method of gathering network data used in several large national surveys, including the General Social Survey (32), the National Health and Social Life Survey (33), and the National Social Life, Health, and Aging Project (34). Some studies assess people's social and sexual networks by asking about connections with a pre-determined list of different social contacts (e.g., parents, partners, individuals who provide material support). We did not impose a conceptual framework that dictated the types of contacts that were most important to BMSM respondents. Instead, we utilized a more open approach (35), which let BMSM respondents reveal the characteristics of their personal social networks. This kept the focus on individuals with whom BMSM respondents were most subjectively engaged (36), which was appropriate given our goal of visualizing a network that includes important individuals most likely to drive any effects of structural positions that individuals occupy. The strong ties generated using this approach was ideal to complement other "weaker" ties that can be elicited through many other approaches including through RDS.

We asked a "name generator" (37) question during the course of face-to-face interviews to elicit a set of social network members who may influence respondent's risky behaviors. The name generator was selected to identify network "confidants" (38) who may have opportunities, through everyday interactions with the respondent, to exercise normative pressure or informal control, provide social support, and to exchange information or advice regarding risky behavior: *"Let's make a list of your closest associates with whom you may share information about yourself, your physical and mental health, and your social and* *sexual lifestyles"*. Names or other identifiers such as nicknames were entered into a roster that was recorded for future reference. We then followed up with a series of "name interpreter" questions about each network member's relationship type, strength of tie, risk behaviors, HIV status and other sociodemographics. This process was looped over each of the five confidants listed from the initial name generator. Research has shown that five network members is optimal for time and effort to field network surveys to determine confidant type ties (39).

Duplicate information and matching algorithm—Before 1999, matching procedures to create unique identifiers using contact tracing and similar network study data have relied on reviewing sorted lists (40–42). Later studies utilized computer matching algorithms (43–48). We adopted the following approach based upon the "fuzzy matching algorithms" developed by a member of the team (SQM), and used in another recent network study (49). Because different respondents within the RDS network are likely to know some of the same people, we created a list of all the network members cited by all of the respondents in our sample, and matched any network members or respondents who we believed to be the same person. Following pre-cleaning to make sure common names were spelled in the same manner, we created a set of rules for matching cases within the network. First, two cases would have to have at least the same initials to be considered as a possible match; having the same full name also meant they were a candidate for being a match. Second, they would have to be within three years difference in terms of their ages. Third, cases would both have to be living in the Chicago area, or both living outside it. Fourth, cases would have to be both of the same race (if one was black, and another was of mixed descent where one of the races was black, they were considered as a possible match). Fifth, cases would both have to be of the same gender, or have approximately the same number of respondents who considered them male, female, or transgender. Thus, a person who was identical on all attributes with some other person, except that one respondent considered that person female and another transgender would be called a match. Sixth, and finally, no two interviewed respondents could be considered for a match.

Following this, we produced a new dataset with attributes for each of these 784 cases. If the case was composed of a respondent, and not simply from a network member (that is, one of the persons which 'compose' this case is someone we actually spoke to), we assigned their HIV status on the basis of HIV testing. If a case was composed of several matched network members, and no respondents, then if at least one respondent listed them as HIV infected, they were coded as such. For all other attributes we took the modal value of their reported attribute. If there was a tie between two modal values, we assigned the respondent an attribute value on the basis of who they were closest to (50). Because eligibility criteria included only MSM, other network members including biologically born women and men who have sex with women only were beyond the scope of the current analysis and the effects of these individuals on MSM have been examined elsewhere (15, 51–53). Members of the team who created the matching algorithm were not involved with any of the subsequent analyses of structural position.

Bridging network metric—In order to calculate each network members' level of bridging we utilized the constraint metric (54):

$$C_i = \left(p_{ij} + \sum_q p_{iq} p_{qi}\right)^2, q \neq i, j,$$

where p_{ij} is the proportion of i's network time and energy invested in contact j, and p_{iq} is the proportion of time and energy of i invested in another contact q. Constraint is a measure of bridging on a 0–1 scale and is low for a given individual who is connected to others who are otherwise not connected to each other. Such an individual with low constraint is one that spans structural holes in the network and can be considered a "bridge". A constraint of 1, a high constraint, represents the lowest bridging and is usually an individual within a network who has only one tie to another network member. In most networks, structural measures are not normally distributed (20, 55); therefore we took the median of the remaining individuals who did not have a low bridging score (constraint=1) to provide a cut-off between moderate bridging and high bridging. Several alternative measures of bridging such as betweeness centrality (56) or link deletion (57) have been identified, but are better suited for larger networks. In order to ease understanding of our results, the terms bridge or bridging are used to signify constraint as just described.

Sociodemographic, Attitude and Behavior Measures—Age, education, employment, HIV status, unprotected and intercourse (UAI), were items adapted from the Centers for Disease Control and Prevention's National HIV Behavioral Surveillance Survey, MSM Cycle (58). Sex drug use (SDU) was measured as in previous work (59, 60) and represented use of any prescription or illicit drug that makes sex easier to get, more enjoyable or last longer. Group sex (GS) was measured as "having sex with two or more individuals at the same time". UAI, GS and SDU were assessed in frequency terms over the past year and were coded for these analyses as present if they were reported as at least monthly. All respondents were tested for HIV (Oraquick Advance HIV 1/2, Bethlehem PA) with confirmation conducted by the Chicago Department of Public Health (OraSure HIV-1 Western Blot). HIV counseling was offered onsite and HIV-infected respondents were linked to HIV care.

Analysis

Risk Network effect analysis—The primary outcomes of this study were defined in terms of risk-related behaviors: UAI, SDU, GS; and HIV status. We examined these outcomes individually according to the following model (61).

$$g(\mathrm{E}(\mathrm{Y}))=\alpha+\beta\mathrm{X}+\lambda\mathrm{Z}$$

where *Y* is the outcome measure, *X* are one or more variables characterizing the respondent's network, and *Z* are the additional covariates selected because of their importance in previous research; individual sociodemographics (age, sexual orientation), risk behavior (UAI, SDU, GS), HIV status, and whether the network member was a respondent or a non-respondent. Our parameter of interest is β, which describes the association between network characteristics and HIV-risk behavior and HIV status practices. Outcome measures were defined as HIV status and the reported frequency of engaging in UAI, SDU, and GS. An ordinal logistic regression model first examined the relationship of structural network metric constraint and one risk behavior outcome controlling for all covariates. A second logistic regression model examined the relationship between constraint and HIV status; again controlling for all covariates.

RESULTS

Matching

Out of a total possible 893 individuals that could make up the network, 85 of them were single matches, 24 of the network members were matched more than once and 6 were isolates (not connected to others in the network). Over half (61%) of matches were perfect name matches. This resulted in a final network size of 778. We examined the concordance for age and HIV status between respondent self-report and reports on these same respondents by other network members. Matched network members were within 2 years of both reports in 92% of cases. For HIV status, there was 79% concordance between self-report of HIV status and report of HIV status by other network members. The majority of discordance (17%) was for respondents self-reporting as HIV uninfected and other network members reporting that they were HIV infected.

Network Composition and visualization

The final analytic network included MSM, MSMW and transgendered persons in the network, limiting the final social network to 620. Individuals who did not meet eligibility criteria were not included (164 women (not transgender) and heterosexual men (20.9%)). These individuals were positioned on the periphery of the network and did not add contribute to the structure of the network (data not shown). Network member characteristics can be found in Table 1. Visualization of the social network can be found in Figure 1. This network graph demonstrates heterogeneity in networks including HIV infected and uninfected individuals within the same personal networks as well as no clear clustering of HIV cases or obvious patterned network structure (ie sub-groups). Calculating bridging for all network members demonstrated low, moderate and high bridging observed in 411 (66.8%), 81 (13.2%) and 123 (20.0%) network members respectively, with several risk factors associated with bridging (Table 2). The sexual network was made up of 81 separate components with the maximum component size including 13 individuals. Meaningful measures and interpretation of bridging within the *sex network* were not possible given the numerous separate components.

Sociodemographic variables and bridging associated with risk behavior and HIV status

In bivariate analysis, the following variables were associated with at least one of the outcome measures (unprotected anal sex, group sex, sex-drug use and HIV status) at the $p<0.1$ level: age, bridging, participant type (respondent vs. named network member not interviewed) and sex partner. Sex behavior variables were not associated with HIV status when analysis was restricted to respondents only, nor the network as a whole. Variables significant at $p<0.1$ from bivariate analyses were entered into separate multiple regression models for each outcome in Table 3. There was a monotonic increase in HIV status with age, a common finding in HIV prevalence studies. As might be expected, risk behaviors (UAI, GS, and SDU) were associated with one another, however, were not associated with HIV status. Moderate and high levels of bridging were associated with HIV status (aOR 3.19; 95% CI 1.58–6.45 and aOR 3.83; 95% CI 1.23–11.95, respectively). When these analyses were rerun including women and heterosexual men, our findings did not change (data not shown).

DISCUSSION

To date, relatively little research has been done on how structural positions within a given social network may be related to the organization of risk behavior and HIV status within the network. In our study on the importance of structural positions, we arrived at a number of significant findings. First, we found that BMSM who were located in bridging positions were more likely to be HIV infected than those who were not. We also noted other characteristics associated with HIV infection, such as increased age and having sex solely with men, but these characteristics are traditionally associated with HIV status among MSM. Of interest, several risk behaviors we observed (unprotected anal sex, group sex, and sex-drug use, for example) were not associated with HIV status, though these behaviors were clustered together due to their associations with one another. This suggests that both HIV-infected and uninfected network members participate in these behaviors and that these behaviors are potentially overlapping. Risk behaviors such as unprotected anal sex can have variable associations with HIV seroprevalence in cross-sectional analyses. HIV-infected MSM, for example, may participate in less unprotected anal sex after learning their HIV status (62, 63), but individuals who are HIV-infected may also be more likely to engage in unprotected anal sex (64, 65) or have more sexual mixing with others regardless of condom use (15). Finally, individuals bridging the network were just as likely as other network members to participate in high-risk sex behaviors such as unprotected anal sex, sex-drug use, and group sex.

Identification of bridges or other structured network positions in HIV research has typically relied on individual level characteristics such as demographic or behavioral factors (22) (66). Most common among these has been the identification of centrally located or popular opinion leaders within high-risk networks. The importance of such centrally located individuals as effective change agents, however, has been limited (23, 67). Other characteristics that are potentially features of bridges, such as one's "innovativeness," have also been described as being potentially associated with bridging position (57). This includes innovativeness among individuals within a high-risk male social network (68). All of these characteristics, however, are subjective measures based on individual reporting that may be associated with structural positions such as bridging or "bridge populations" – and thus they are potentially susceptible to misclassification.

Others frame bridging quantitatively within the context of mixing between groups or as a discordance between sex partners whereby one partner belongs to a low risk "core" group and another from a high risk group (69). Within this kind of framing, bridging has been found to exert a greater influence on HIV status as compared to other drivers of HIV transmission such as concurrency (70). This has been extended to spatial bridging both for the transmission of sexually transmitted infections and HIV (71–73). These bridging network structures may accelerate or limit the spread of disease across an entire community and may be a decisive factor in determining whether epidemics are concentrated or generalized (74) within a specified boundary.

All of these bridging measurements, however, are not based on a quantified bridging structural position as in this study. We are not the first to use quantitative methods, but the actual quantification of bridges through social network metrics has mostly been conducted by researchers who study organizational structure (e.g., Burt(55)). While our findings provide a glimpse into the relationship between bridging and HIV status, the organizational sciences have developed a rich literature as to the behaviors related to bridging positions, which may help us develop interventions based upon the structural identification of bridges.

Bridges may be more efficient diffusion agents than centrally located individuals because they have fewer interconnected network members to persuade (75); they can also devote more energy to persuading and thereby be more effective change agents. Additionally, bridging individuals may be more receptive to behavior change because they have less pressure to support prevailing norms and behaviors (76) or incur a reputation cost for new and potentially disapproved behavior (25). Finally, occupying a bridging position may be indicative of attitudinal dispositions such as being open to new ideas and practices (57, 77). By virtue of their boundary-spanning positions, bridging individuals often have early access to novel information, but are also experienced in communicating the information across diverse audiences (25). Recognizing the limitations of cross-sectional data in this study, identification of bridges within a high-risk network may be of importance not only because of the potential to target such individuals to limit onward transmission through a community, but also because of the potential to recruit such individuals as change agents to intervene at the network level.

As with any study, our findings must be interpreted within the context of study limitations. One limitation is due to the cross-sectional nature of our network data, which does not allow us to determine causality. We do not know whether a bridging position leads to HIV infection, or whether individuals gravitate to bridging positions following a diagnosis of HIV (perhaps through network partitioning), or both. Risk network researchers, for example, may suggest that bridges are positioned to become HIV-infected, but this assumes that the social network approximates the sexual, which it did not in this study. Similarly, organizational network researchers might posit that HIV infected persons position themselves strategically to control information flow, connecting to relatively isolated individuals who are otherwise not connected. Both of these hypotheses could be valid and warrant further research to determine how network position might be related to HIV serostatus in a social network. A second limitation is that our network does not include all ties or individuals, including women, and may not represent all BMSM. Women and heterosexual men did not contribute to the structure of this network (data not shown). Previously we have estimated that there are nearly 10× the number of MSM in this area than what were included in our sample (78), although we do not know if they are all part of one network component. Given the chain referral sampling methods utilized and boundary specification (79) which limited our sampling frame to the South Side of Chicago, we developed a fair amount of network redundancy making the network we characterized a likely sub-network within the South Side. Limiting our focus to closer associates may have excluded some weak ties, although at least some weak ties were included through RDS chains. Including additional weak ties (e.g., by using a roster or density matrix) could improve social network research for MSM. Using one name generator may limit the number of strong or close ties evident in the network. Additionally, we did not measure whether the confidants in fact provided social support, information control and exchange of information or advice. Regardless, we wished to keep the focus on individuals with whom BMSM were most subjectively engaged (36), which was appropriate given our goal of visualizing a network that includes important individuals most likely to drive any effects of structural positions that individuals occupy. Other approaches to network generation could be considered, including using multiple name generators concurrently that get at specific functions (ie. provide social support, inject drugs with etc.)(80, 81). Other individuals who were not eligible for participation such as women and heterosexual men may play important roles in the lives of BMSM (15, 51, 52). Finally, our matching algorithm might produce misclassifications with respect to risk behaviors and HIV status. While our matching algorithm is similar to that used in other risk network studies (43–48), full last names were less common, which could lead to misidentification of network members. Despite this, our concordance rate between self-reported HIV status and behavior and the reports of others on that behavior and HIV status was high at nearly 80%. It is difficult to predict which of the biases inherent to our data collection methods might have predominated. For example, social desirability bias is commonly present during risk surveys and the high rate of HIV positive unaware (15% overall and 50% in those under 20 years of age) may have been underestimated in our self-reported HIV status prevalence. Both of these forces may make reports on one's HIV status from close confidants potentially more accurate than self-reports. Regardless, new approaches to validate, improve or weigh the accuracy of reports on network members are needed.

This study demonstrates that network structure as an emergent property in HIV prevention may be of importance when classifying at-risk individuals or at least identifying individuals who may be HIV infected. This could complement traditionally utilized individual level risk, and allow for more effectively targeted HIV prevention interventions both at the individual level, as well as the network level where halting transmission pathways is critical. Moreover, identification of bridges could be explored in future interventions to serve as change agents to diffuse novel prevention modalities through high-risk networks.

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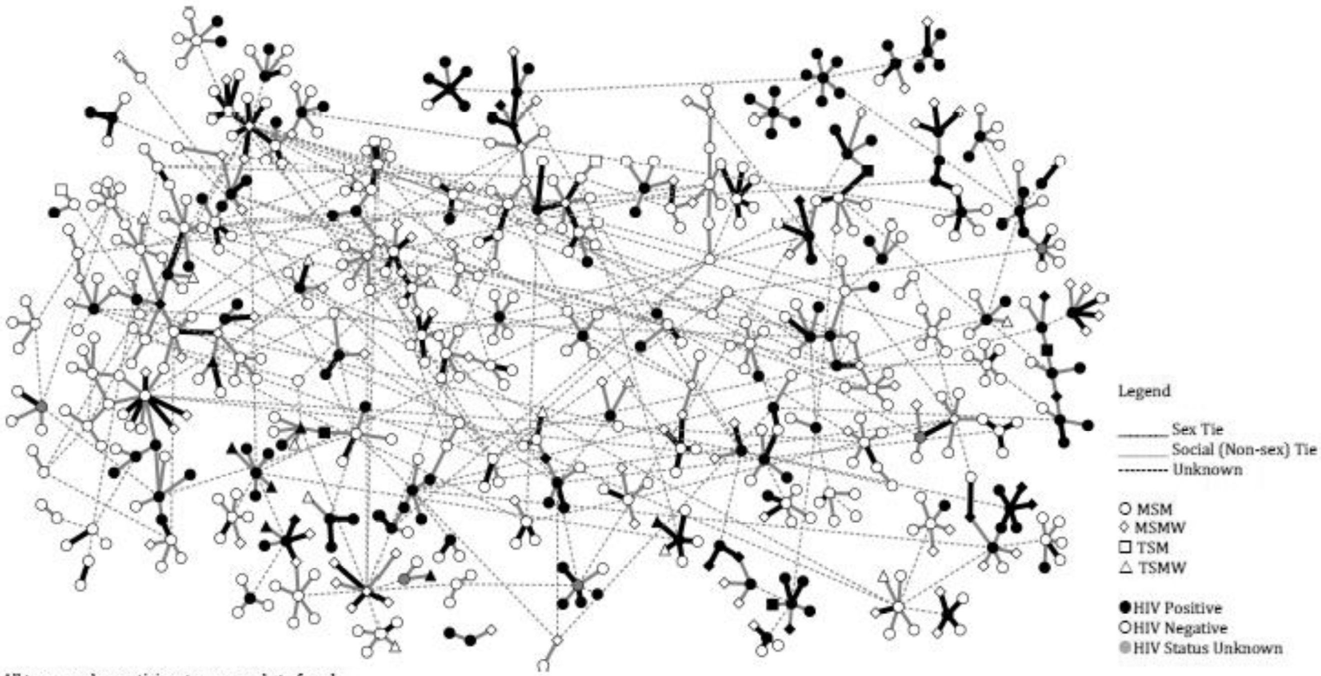


All transgender participants were male to female.
MSM: Men who have sex with men; MSMW: Men who have sex with men and women
TSM: Transgender individuals who have sex with men; TSMW: Transgender individuals who have sex with men and women

Figure 1. Social network of Black men who have sex with men (n=620), South Chicago, United States

Table 1

Attributes for Black men who have sex with men and their network members (n=620)

Characteristics	**Respondents (n=154) N (%)**	**Network Members (n=466) N (%)**
Age		
<20	23 (14.9)	63 (13.5)
20–24	47 (30.5)	131 (28.1)
25–30	28 (18.1)	102 (21.9)
31–40	19 (12.3)	61 (13.1)
41+	28 (18.2)	108 (23.2)
Race		
Black/African-American	144 (93.5)	440 (94.4)
White/Caucasian	0 (0)	10 (2.1)
Native American	0 (0)	2 (0.4)
Mixed/other	9 (5.8)	13 (2.8)
Gender		
Male	151 (98.1)	430 (92.3)
Transgender Female	0 (0)	24 (5.2)
Sex Partners		
Men only	142 (92.2)	345 (74.0)
Men and Women	7 (4.5)	80 (17.2)
Other/Unknown	3 (1.9)	15 (3.2)
Unprotected anal sex*	48 (31.2)	163 (35.0)
Sex drug use*	48 (31.2)	269 (57.7)
Group sex*	32 (20.8)	104 (22.3)
HIV Status†		
HIV+	66 (42.9)	109 (23.4)
HIV−	87 (56.5)	352 (75.5)
Unknown	1 (0.6)	5 (1.1)

*Risk behavior variables were measured over the previous 12 months.

†From among respondents indicating that they know network members' HIV status Data missing: 10 for age, 2 for race, 28 for sex partners, 6 for HIV, 84 for UAS, 63 for SDU, 67 for GS

TABLE 2

Ordinal logistic regression of sociodemographic factors, risk behaviors and HIV infection against bridging in a Black men who have sex with men network in Chicago (n=620).*

Characteristic	(N=620)	Low Bridging (aOR; 95% CI)	Moderate Bridging (aOR; 95% CI)	High Bridging (aOR; 95% CI)
Age				
<20	(86)	Ref	Ref	Ref
20–24	(178)	0.71; (0.25–2.06)	0.82; (0.39–1.71)	2.58; (0.83–7.98)
25–29	(130)	0.91; (0.29–2.89)	0.58; (0.25–1.34)	5.23†; (1.14–24.58)
30–39	(80)	1.77; (0.44–7.08)	0.37; (0.13–1.04)	4.30; (0.76–24.21)
>39	(136)	2.70; (0.77–9.51)	0.37†; (0.15–0.90)	1.62; (0.41–6.52)
Sex partners				
Men only	(487)	Ref	Ref	Ref
Men and Women	(101)	0.23‡; (0.11–0.46)	3.41‡; (1.83–6.38)	0.74; (0.14–3.90)
Group sex				
Not in the past 6 months	(417)	Ref	Ref	Ref
In the past 6 months	(136)	2.66†; (1.09–6.47)	0.64; (0.33–1.25)	0.49; (0.16–1.46)
HIV				
Negative	(439)	Ref	Ref	Ref
Positive	(135)	0.32‡; (0.15–0.69)	1.90†; (1.06–3.41)	1.33; (0.49–3.58)

*Variables significant from bivariate analysis also used in regressions with p=0.10 as cutoff included respondent type, unprotected anal sex, sex-drug use and gender

†p<0.05

‡p<0.01, Ref=reference group.

TABLE 3

Multiple logistic regression analysis including sociodemographic, risk behavior and bridging variables for unprotected anal sex, group sex, sex-drug use and HIV infection of a Black men who have sex with men network in Chicago (n=620).

Characteristic (N=620)		**Unprotected anal sex[1] (aOR; 95% CI)**	**Group sex[2] (aOR; 95% CI)**	**Sex-drug use[3] (aOR; 95% CI)**
Age				
<20	(86)	Ref	Ref	Ref
20–24	(178)	0.76; (0.39–1.47)	0.48; (0.22–1.03)	3.55‡; (1.75–7.20)
25–29	(130)	0.63; (0.30–1.30)	1.07; (0.48–2.36)	5.53‡; (2.52–12.15)
30–39	(80)	0.52; (0.23–1.19)	0.58; (0.23–1.47)	6.42‡; (2.71–15.22)
>39	(136)	0.63; (0.31–1.28)	0.58; (0.26–1.30)	3.45†; (1.65–7.22)
Sexual behavior		-		
MSM	(487)	-	Ref.	Ref
MSMW	(101)	-	1.69; (0.90–3.15)	1.41; (0.76–2.60)
Bridging			-	
Low (1)	(411)	Ref	-	Ref
Moderate (0.18–0.99)	(81)	0.99; (0.36–2.73)	-	0.97; (0.30–3.10)
High (0–0.17)	(123)	0.65; (0.19–2.19)	-	3.64; (0.64–20.83)
Unprotected anal sex		N/A		
Not in the past 6 months	(325)		Ref	Ref
In the past 6 months	(211)		6.09‡; (3.67–10.10)	3.20‡; (1.97–5.20)
Group sex			N/A	
Not in the past 6 months	(417)	Ref		Ref
In the past 6 months	(136)	5.95‡; (3.63–9.76)		3.13‡; (1.70–5.75)
Sex-drug use				N/A
Not in the past 6 months	(240)	Ref	Ref	
In the past 6 months	(317)	2.95‡; (1.85–4.70)	3.32‡; (1.81–6.11)	
Participant type				
Study respondent	(154)	Ref	Ref	Ref
Network member	(466)	1.96; (0.64–5.96)	0.51*; (0.28–0.94)	1.52; (0.33–7.10)

Variables included in each of the four models from bivariate analysis at p=0.10 but not significant after adjustment here are the following:

[1] age, bridging, participant type;

[2] age and sexual behavior;

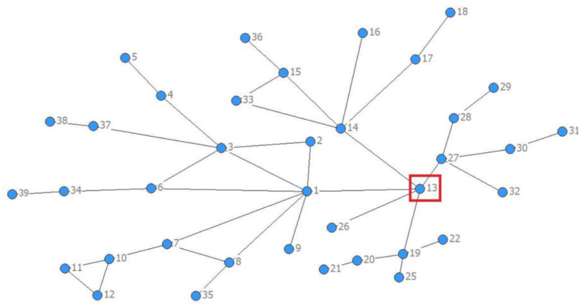
[3] sexual behavior, bridging and participant type;

[4] Participant type.

* p<0.05,

† p<0.01,

‡p<0.001. N/A = not applicable. Ref=reference group.



Network demonstrating concept of bridging This hypothetical network illustrates the bridging node. At first, Node 1 appears to be an important node because it has more direct connections to other individuals in the network1. In contrast, node 13 has fewer direct connections to other individuals in the network. While node 13 has fewer connections to others in the network and can be considered less popular, node 13 acts as a bridge in the network. Having direct connections to three distinct subpopulations in the network, node 13 is best positioned to connect nodes in the network that are otherwise not connected.2

1. Degree centrality is a measure that indicates the node with the greatest number of connections. Node 1 has the highest degree centrality (7.0) because node 1 has more connections to other individuals than any other node in the network.
2. Constraint is a measure of bridging on a 0–1 scale and is low for a given node that is connected to others who are otherwise not connected to each other. Node 13 has the lowest constraint score (0.2) because this node has access to the range of the network by representing key bridges to distinct sub-groups.