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Neighborhood-Level Associations with HIV Infection Among Young Men Who Have Sex with Men in Chicago

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Abstract The rising incidence of HIV infection among young men who have sex with men (YMSM) is a substantial public health concern. Traditional research on HIV among YMSM has focused largely on individual-level predictors and infrequently accounts for contextual or neighborhood-level factors such as ethnic composition and socioeconomic status. This study used neighborhood-level data from the US Census and other public sources, and individual-level data from a longitudinal cohort of YMSM in Chicago (Crew 450). Of the original 450 YMSM in the cohort, 376 reported living in Chicago (83.6 %) and were included in the analytic sample. A clustering approach was used to group the 77 community areas together by common characteristics, resulting in the identification of 11 distinct clusters. An unconditional model of individual HIV status indicated a significant amount of variance existed between neighborhood clusters ($\chi^2 = 21.66$; $p = 0.006$). When individual-level variables were added to the model, only having an HIV-positive sex partner (OR = 6.41; CI 2.40, 17.1) and engaging in exchange sex in the past 6 months (OR = 3.25; 95 % CI 1.33, 7.93) were significant predictors of HIV status. Clusters with higher Walk Scores were less likely to contain HIV-positive individuals (OR = 0.94; 95 % CI 0.90, 0.98). Conversely, clusters with a larger proportion of vacant buildings were more likely to contain HIV-positive individuals (OR = 1.19; 95 % CI 1.07, 1.33). Future research among YMSM needs to investigate the mechanisms by which neighborhood of residence might influence engagement in risk behaviors or acquisition of HIV.

Keywords HIV · Young MSM · Neighborhood-level factors · Cluster analysis · Hierarchical linear modeling · Sexual orientation

Introduction

The incidence of HIV infection in the United States among young men who have sex with men (YMSM) aged 13–24 years, is a substantial public health concern. According to the Centers for Disease Control and Prevention (CDC), HIV diagnoses among YMSM increased 22 % from 2008 to 2010 (CDC, 2014), and MSM aged 13–29 years accounted for 69 % of all new diagnoses in 2009 among that age group (Prejean et al., 2011). These numbers are disturbing and do not account for undiagnosed infections which may be as high as 54 % (CDC, 2010; Mustanski, Newcomb, Du Bois, Garcia, & Grov, 2011). Despite the high risk of HIV acquisition among YMSM, there has been little research conducted on this population, especially with YMSM under the age of 18 (Mustanski et al., 2011). In order to gain a greater understanding of the spread of HIV among YMSM, researchers have begun to take a multifaceted approach which acknowledges that individual-level, dyadic-level, network-level, and neighborhood-level factors all play an important role in predicting and driving the HIV epidemic (Gorbach & Holmes, 2003; Johnson et al., 2010; Mustanski et al., 2011).

At the individual-level, key behavioral factors associated with HIV infection include use of drugs and/or alcohol before or

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during sex (Cooper, 2002; Scott-Sheldon, Carey, & Carey, 2010), engagement in condomless anal sex (Walsh, Senn, Scott-Sheldon, Vanable, & Carey, 2011), and exchanging sex for money or drugs (Marshall, Shannon, Kerr, Zhang, & Wood, 2010). Other predictors include relationship type (i.e., serious vs. casual) (Misovich, Fisher, & Fisher, 1997; Newcomb, Ryan, Garofalo, & Mustanski, 2014a) and knowledge about and attitudes toward HIV (Fisher, Williams, Fisher, & Malloy, 1999; Walsh et al., 2011). However, these individual-level correlates are not universal predictors across all YMSM. Although Black YMSM have the highest incidence of HIV infection, they are more likely to use condoms, have fewer sex partners, and use drugs and alcohol less frequently than other racial/ethnic YMSM (Clerkin, Newcomb, & Mustanski, 2011; Millett, Flores, Peterson, & Bakeman, 2007; Mustanski & Newcomb, 2013; Newcomb, Ryan, Greene, Garofalo, & Mustanski, 2014b; Rosenberger et al., 2012). Thus, individual-level factors cannot be the only predictors of HIV acquisition, and we must therefore investigate other explanations, including the roles that dyadic interactions, network characteristics, and neighborhood-level factors play.

Traditional research on HIV prevalence and prevention has focused largely on individual-level predictors and has rarely taken into account contextual or neighborhood-level factors, so is therefore reductionistic in nature (Halkitis, 2010; Martin, 2006). Research findings have shown that an encompassing approach, one that accounts for more than just individual-level factors, is necessary for a richer understanding of HIV acquisition and transmission, which could then be translated into more effective HIV prevention programs (Dragowski, Halkitis, Moeller, & Siconolfi, 2013; Eisenberg, Bauermeister, Pingel, Johns, & Santana, 2011; Halkitis, 2010). D'Augelli (2012) suggests that studying young sexual minorities without considering social, institutional, and historical elements is fundamentally distorted because these contexts shape development.

The risk of HIV infection among the general population and among MSM is influenced by a number of neighborhood-level factors including access to HIV-specific resources, ethnic composition, and socioeconomic status (SES) (Choi, Ning, Gregorich, & Pan, 2007; Drumright & Frost, 2010; Hao et al., 2014; McKirnan & Peterson, 1989). Depression and substance use, which are predictors of HIV, tend to cluster by neighborhood as well (Crosby & Grofe, 2001; Truong & Ma, 2006). Among MSM, substance use and engagement in condomless sex have both been found to be linked to residence within gay neighborhood, but the direction of this association has been variable across studies (Buttram & Kurtz, 2013; Carpiano, Kelly, Easterbrook, & Parsons, 2011; Frye et al., 2010; Mills et al., 2001). Additionally, researchers have identified subcategories of neighborhoods—home, social, and sexual—that could convey different risks and protective factors to MSM (Koblin et al., 2013). Despite these findings, there is a dearth of research on the role that neighborhood-level factors play in explaining the incidence and prevalence of HIV specifically among YMSM (Amirkhanian, Kelly, & McAuliffe, 2005).

Dragowski et al. (2013) draw upon an ecological framework to explain that studying the influence of neighborhood-level factors is important in expanding our understanding of HIV transmission. The nature of a neighborhood, such as racial/ethnic composition or SES, can be a risk factor (e.g., due to lack of access to health resources) or play a protective role (e.g., reduced drug use) (Buttram & Kurtz, 2013). For instance, findings have shown that MSM who live in a lower SES neighborhood are more likely to engage in high-risk sexual behaviors (Peterson et al., 1996). Neighborhood composition, such as the number of sexual minority individuals, may be critical for YMSM since the neighborhood can either offer protective factors, like community resources tailored to MSM, or detrimental factors, such as high levels of substance use (Dragowski et al., 2013; Mays, Cochran, & Zamudio, 2004; Mustanski et al., 2011). Additionally, the residents within a neighborhood may share beliefs and values which are often related to HIV transmission (Kelly et al., 2010; Tobin & Latkin, 2008). For example, neighborhoods can play a protective role for African-American MSM by offering social support regarding identity and prejudice (Wohl et al., 2011; Wong, Schrager, Holloway, Meyer, & Kipke, 2014). Alternatively, MSM of color may face additional homophobic oppression and stigma in their neighborhoods which is associated with poor outcomes like HIV infection (Bianchi et al., 2007; Egan et al., 2011). Another example posits that neighborhood-level factors such as lacking safe places to socialize and appropriate leisure time activities may be associated with sexual risk (Akers, Muhammad, & Corbie-Smith, 2011).

Although most studies have exclusively focused on individual-level factors as the key predictors of HIV acquisition, some have suggested that contextual components could play a larger role (Amirkhanian, 2014; Smith, Grierson, Wain, Pitts, & Pattison, 2004). In other words, network structure and neighborhood-level factors may be stronger predictors of HIV transmission than individual behavior: having sex with someone who lives in a community with high HIV prevalence puts one at greater risk for HIV acquisition than having sex with someone in a low prevalence community (Laumann & Youm, 1999; Mimiaga et al., 2009; Rothenberg, Baldwin, Trotter, & Muth, 2001). Perhaps the relation between behavior and outcome is influenced by the context in which it is occurring (Carpiano et al., 2011). Some research has looked at neighborhood-level factors (Youm, 2010), but more work needs to be done to help tease out reasons why HIV incidence has continued to increase among YMSM while decreasing among other risk categories. The goal of this study was to explore how neighborhood-level factors such as demographics, SES, immigration status, crime, and drug use are associated with the prevalence of HIV among YMSM parallel to, and in conjunction with, individual-level predictors. Findings will hopefully help in understanding the complexities of HIV transmission and acquisition among YMSM beyond the scope of individual-level factors.

Method

Participants and Procedure

Data were collected as part of a longitudinal study of YMSM (Crew 450) conducted in Chicago and its surroundings starting in December 2009. In order to be eligible for this study, an individual had to be assigned male sex at birth, aged 16–20 years, an English speaker, report a sexual encounter with a male or a gay/bisexual identity, and available for 2 years of follow-up. A modified form of respondent-driven sampling (RDS) was used to recruit 450 YMSM. More details on the sampling methodology have previously been published (Kuhns et al., 2015).

This article used data collected at the baseline (T1) and 12 month follow-up visits (T3). At each of these visits, participants were administered a computer-assisted self-interview (CASI) with audio instructions that took about 1 h to complete. They were also tested for HIV, gonorrhea, and chlamydia at these two time points. HIV status was assessed using a rapid oral screening test (OraQuick ADVANCE 1/2; OraSure Technologies, Bethlehem, PA) for participants with a negative or unknown status. For those who self-identified as HIV-positive or had a preliminary positive on the rapid oral screening test, 86.8 % were confirmed by OraSure testing, medical records, or verification of HIV-specific antiretroviral medication. Urethral gonorrhea and chlamydia infections were determined via urine polymerase chain reaction (PCR). Participants were compensated $45 for their time. All procedures were reviewed and approved by the Institutional Review Boards (IRBs) at the participating institutions.

Of the 450 participants in the study, 376 (83.6 %) reported living within the city limits of Chicago and were included in these analyses. The sample of 376 participants consisted predominantly of Black YMSM (53.5 %), followed by 21.0 % Hispanic and 16.5 % White YMSM. Mean age of participants was 18.9 years (standard deviation = 1.29 years), with ages ranging from 16.1 to 21.0 years. Nearly half identified as "only gay/homosexual" (48.4 %), with equal proportions identifying as "mostly gay/homosexual" and "bisexual" (22.9 % each).

At baseline, 29 (7.7 %) of participants were identified as HIV-positive, and 33 (8.8 %) tested positive for either urethral gonorrhea or chlamydia. At T3, the prevalence of HIV increased to 12.0 % ($n = 45$) and the total incidence of gonorrhea or chlamydia over the 12-month period increased to 14.4 % ($n = 54$).

Measures

Individual-Level

Participants asked questions about their age, race/ethnicity, and sexual identity at baseline. The survey also included questions about the participant's sexual behavior in the prior 6 months. They were asked to report number of receptive and insertive anal sex partners and whether or not any of those sex acts were condomless. Additional questions assessed attributes of their three most recent sexual partners; these included how they met the partner, type of partner (serious, casual, one-night stand, anonymous), partner's HIV status, and whether or not alcohol or drugs were used before or during sex with the partner. Questions were asked about use of a list of drugs in the prior 6 months: marijuana, cocaine, heroin, methamphetamines, opiates, prescription depressants, prescription stimulants, psychedelics, ecstasy, ketamine, inhalants, and poppers. Participants who reported use of any drugs except marijuana were classified as "hard drug" users for the purposes of this article.

Neighborhood-Level

During the 1920s, the University of Chicago and the Chicago Department of Public Health (CDPH) collaborated to divide Chicago into 75 distinct regions, or community areas (Seligman, 2005). Since that time, only two additions have been made to the community area map of the city—O'Hare (community area 76) was added in the 1950s, and Edgewater (community area 77) was added in 1980.

Characteristics of each community area were extracted from public sources. Age, race/ethnicity, and gender distributions came from the 2010 United States Census (FactFinder, 2010). Information on educational attainment, annual income, heads of households, birth outside of the United States, and residential movement in the prior year came from the 2012 American Community Survey (ACS) (FactFinder, 2012a, b, c, d). Number and proportion of vacant houses came from the Woodstock Institute, which is a research institution based in Chicago (2012). Researchers frequently use the presence of vacant houses as an indicator of blight related to neighborhood-level poverty and crime (Garvin, Branas, Keddem, Sellman, & Cannuscio, 2013). Prevalence and incidence rate of HIV among males aged 15–24 years (per 100,000) between 2009 and 2010 were provided by CDPH. Total chlamydia incidence rates were found in the HIV/STI Surveillance Report published by CDPH in December 2013 (Chicago Department of Public Health, 2013). The number of violent crimes (homicide, criminal sexual assault, robbery, aggravated assault, and aggravated battery) and drug arrests in the prior year was calculated by community area using the Chicago Police Department website (CPD, 2014).

Centroids (i.e., geographical center) for each community area were calculated using the Calculate Geometry function in ArcGIS. The address for each centroid was entered into a calculator online (http://www.walkscore.com) to generate Walk Scores and Transit Scores for each community area. These scores range from 0 to 100 and assess two measures of accessibility. A low Walk Score indicates that an area requires a car to complete errands, while a high Walk Score indicates that daily errands can be done without a car. A low Transit Score means that the area does not have many public transportation options, whereas a high Transit Score indicates an area has a wide area of transit options. These scores have been used by public health researchers to study the effects of environment on physical health and obesity (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Berry et al., 2010; Duncan, 2013). In this analysis, these scores were used as indicators of mobility within Chicago; participants who lived in communities with low Walk Scores and Transit Scores are less able to seek resources (jobs, HIV prevention, etc.) outside their current neighborhood.

Analytic Strategy

First, in order to compare neighborhood-level influences on health, adequate individual observations of health are needed within each neighborhood division (Diaz et al., 2001). Although 376 Crew 450 participants reported living in Chicago, none resided in 17 (22.1 %) of the 77 community areas, 12 community areas (15.6 %) only had 1 resident, and 12 community areas (15.6 %) only had 2 residents. Due to the large proportion of Chicago community areas with 2 or fewer observations, community area was not the optimal neighborhood-level division. Sparse individual-level data within neighborhood-level data have been shown to be problematic in the development of multilevel estimates of associations (Bell, Ferron, & Kromrey, 2008; Clarke & Wheaton, 2007). Of specific concern are neighborhoods with two or fewer individual observations (Clarke, 2008); models with sparse and unbalanced data demonstrated highly biased estimates. Therefore, a clustering approach was used to group community areas together by common characteristics. This approach has been used in many health-based studies to group together census tracts and block groups based on SES (Onifade, Peterson, Bynum, & Davidson, 2011; Wilson, Kirtland, Ainsworth, & Addy, 2004), race (McWayne, McDermott, Fantuzzo, & Culhane, 2007; Sucoff & Upchurch, 1998), and crime statistics (Plybon & Kliewer, 2001) and investigate neighborhood-level influences.

Ward's Minimum Variance Cluster Analysis was conducted in SAS v9.3 (Cary, NC) using PROC CLUSTER. Community area-level variables used to create clusters were proportion of Black residents, proportion of Hispanic residents, proportion of residents living below poverty, number of violent crimes in the prior year, number of drug arrests in the prior year, Transit Score, Walk Score, ethnic heterogeneity—calculated using the formula: $[1-(\%\,\text{White}^2+\%\,\text{Black}^2+\%\,\text{Hispanic}^2)]$ (Frye et al., 2010), proportion of same-sex headed households, proportion of residents who had moved in the prior year, proportion of residents born outside the United States, proportion of single-parent headed households, proportion of vacant buildings, proportion of male residents, proportion of residents over the age of 65, proportion of residents with less than a high school education, and proportion of residents with at least a Bachelor's degree. Indicators selected for inclusion in the cluster analysis replicated those used by Frye et al., with the addition of crime statistics and mobility statistics. Proportion of residents over the age of 65 was included as another indicator of SES—older individuals are less likely to be employed and more likely to be on a fixed income.

Determination of the optimal number of clusters was done using two statistics—the cubic clustering criterion (CCC) (SAS Institute Inc., 1983) and the pseudo t^2 index. The CCC identified two peaks at 3 and 11 clusters, and the pseudo t^2 index indicated valleys at 4, 9, and 11 clusters. Therefore, an 11-cluster solution was selected since both criteria identified this as an optimal choice. Results are presented in Table 1 and Fig. 1.

Clusters were used to first stratify and compare Crew 450 participant data on drug/alcohol use, high-risk sexual behavior, and HIV/STI status across two waves of observations (Table 2), and then to stratify and compare HIV and chlamydia infection rates from CDPH by neighborhood cluster (Table 3). All preliminary analyses were conducted in SAS v9.3. Significant differences in neighborhood-level characteristics were assessed through analysis of variance (ANOVA) procedures, whereas differences in individual-level characteristics were assessed through logistic regression modeling. Finally, clusters were used to analyze the HIV status of Crew 450 participants via multilevel modeling using hierarchical linear modeling (HLM) 7.0 statistical software (Raudenbush & Bryk, 2002; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011). First an unconditional model was estimated, and χ^2 was calculated to reveal if significant variation between clusters existed. If so, multilevel modeling was performed in which all individual-level and neighborhood-level factors were entered individually into the model to determine if they significantly accounted for individual- and neighborhood-level variance in HIV status.

Results

Preliminary Neighborhood Cluster Comparisons of YMSM Risk Behaviors and Health

Crew 450 data were grouped by cluster, with the number of participants ranging from 3 (0.8 %) to 115 (30.6 %). Two clusters with less than 5 observations were excluded from any cross-cluster comparisons (i.e., Clusters 8 and 11). Cluster 7 was chosen as the comparison cluster for all cross-cluster analyses for three reasons: (1) it contained the largest number of Crew 450

Table 1 Means and SDs by cluster for neighborhood-level characteristics

	Community area clusters																						Chicago
	1		2		3		4		5		6		7		8		9		10		11		
	M (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)	f	*M* (SD)
Neighborhood characteristics																							
% Black[a]	3.5 (3.6)		93.4 (5.9)	↑	2.8 (1.2)		11.0 (20.0)		17.8 (6.7)		86.1 (12.7)	↑	12.5 (11.6)		13.5 (21.7)		40.0 (9.5)		85.0 (–)	↑	96.0 (–)	↑	39.1 (40.3)
% Hispanic[a]	80.5 (6.7)	↑	3.5 (5.3)		46.5 (12.7)		14.6 (10.1)		14.3 (8.7)		6.0 (9.4)		14.6 (14.2)		52.5 (17.8)		51.7 (6.1)		9.0 (–)		2.0 (–)		25.5 (28.0)
Ethnic heterogeneity[a]	0.33 (0.09)		0.12 (0.09)		0.62 (0.11)	↑	0.47 (0.17)		0.75 (0.15)	↑	0.23 (0.18)		0.54 (0.14)		0.52 (0.11)		0.56 (0.01)		0.27 (–)		0.08 (–)	↓	0.39 (0.23)
% Male[a]	51.4 (2.2)	↑	44.8 (1.2)	↓	50.1 (1.0)		48.3 (1.2)		50.6 (1.8)		44.5 (2.0)	↓	48.8 (1.4)		49.0 (0.8)		49.0 (1.3)		45.9 (–)		41.1 (–)	↓	47.8 (3.0)
% >65 years[a]	6.9 (1.4)	↓	12.2 (2.9)		9.6 (2.0)		14.9 (2.6)		12.0 (4.7)		16.5 (3.9)	↑	8.5 (2.5)		11.7 (2.5)		6.8 (0.5)	↓	10.8 (–)		6.0 (–)	↓	11.4 (4.2)
% <HS edu.[b]	42.5 (8.8)	↑	22.8 (5.9)		26.0 (5.5)		12.4 (5.6)		19.5 (12.5)		17.5 (6.6)		7.9 (5.2)	↓	22.6 (8.7)		36.9 (5.4)	↑	25.0 (–)		24.6 (–)		21.6 (12.4)
% Living in poverty[b]	20.2 (6.1)		33.8 (7.4)	↑	15.2 (3.4)		8.1 (4.4)	↓	24.8 (5.4)		26.9 (9.1)		15.2 (6.0)		12.7 (6.0)		30.4 (5.0)		27.7 (–)		60.0 (–)	↑	21.6 (11.6)
% Moved in last year[b]	11.9 (4.3)		17.8 (4.1)		12.9 (2.7)		7.8 (2.5)	↓	18.1 (3.7)		13.9 (5.9)		23.9 (5.0)	↑	9.8 (3.5)		12.9 (1.6)		13.9 (–)		18.3 (–)		14.8 (6.4)
% Single-parent households[b]	35.7 (6.9)		79.7 (8.2)	↑	33.8 (4.0)		21.2 (8.3)	↓	39.1 (2.2)		69.4 (8.3)		28.9 (15.2)		40.7 (5.0)		56.9 (9.3)		72.6 (–)	↑	93.0 (–)	↑	47.8 (24.0)
% Foreign-born[b]	40.4 (3.6)	↑	2.5 (2.9)	↓	36.6 (5.5)	↑	23.1 (15.1)		34.4 (12.6)		6.5 (5.0)		17.0 (4.9)		19.6 (9.0)		22.5 (5.5)		4.0 (–)		0.8 (–)	↓	19.2 (15.4)
% Same-sex households[b]	3.0 (2.7)		6.4 (4.5)		8.3 (3.9)		13.8 (8.1)		34.6 (7.3)	↑	9.8 (7.8)		12.3 (5.7)		1.0 (1.3)		2.4 (1.6)		6.3 (–)		21.1 (–)	↑	9.8 (9.0)
# Violent crimes[c]	191.6 (141.8)		672.0 (212.0)	↑	151.5 (76.4)		67.5 (64.8)		197.8 (86.1)		150.4 (97.9)		264.8 (175.6)		96.0 (85.1)		669.0 (135.5)	↑	1676.0 (–)	↑	137.0 (–)		300.4 (305.8)
# Drug arrests[c]	191.2 (123.2)		954.0 (621.7)		136.0 (111.7)		81.8 (75.1)		234.5 (195.2)		121.4 (97.8)		152.2 (114.5)		88.0 (52.0)		1336.0 (1110.3)	↑	4228.0 (–)		62.0 (–)		396.1 (673.7)
Transit score[d]	61.7 (2.2)		65.5 (5.2)		63.0 (3.8)		53.6 (6.0)		74.3 (3.0)	↑	62.0 (6.6)		78.3 (11.1)	↑	47.3 (9.0)	↓	60.7 (5.5)		64.0 (–)		56.0 (–)		63.5 (10.3)
Walk score[d]	73.1 (6.9)		66.1 (6.6)		78.2 (5.9)		61.9 (10.0)		86.0 (4.7)	↑	61.2 (9.2)		90.3 (6.1)	↑	56.8 (3.8)	↓	72.7 (9.7)		74.0 (–)		32.0 (–)	↓	70.6 (13.5)
% Vacant buildings[e]	3.9 (1.0)		11.3 (2.4)	↑	3.8 (0.7)		2.7 (1.1)		3.5 (1.4)		7.2 (2.5)		3.7 (0.8)		4.4 (1.5)		9.8 (2.1)		7.0 (–)		27.8 (–)	↑	6.1 (4.4)
No. of community areas	10		15		6		12		4		10		11		4		3		1		1		77
Community area components	19, 20, 30, 31, 57, 58, 59, 62, 63, 65		26, 27, 29, 38, 40, 42, 43, 44, 46, 49, 53, 67, 68, 69, 71		14, 15, 16, 18, 21, 60		2, 9, 10, 11, 12, 13, 17, 56, 72, 74, 75, 76		1, 3, 34, 77		35, 36, 37, 39, 45, 47, 48, 50, 51, 73		4, 5, 6, 7, 8, 22, 24, 28, 32, 33, 41		52, 55, 64, 70		23, 61, 66		25		54		1-77

[a] Data from 2010 United States Census

[b] Data from 2008 to 2012 American Community Survey

[c] Data from Chicago Police Department

[d] Data from http://www.walkscore.com

[e] Data from Woodstock Institute

[f] Symbol ↓ = Cluster mean is greater than 1 SD below the mean for all Chicago Community Areas. Symbol ↑ = Cluster mean is greater than 1 SD above the mean for all Chicago Community Areas

Clusters have significantly different means ($p < 0.0001$) for all neighborhood-level characteristics participants and was therefore the most stable comparator; (2) it was the second most average cluster using scaled deviations from the means of all neighborhood characteristics across clusters; (3) it included the "Boystown" neighborhood, the official city-recognized cultural center of the lesbian, gay, bisexual, and transgender (LGBT) community in Chicago.

There were no differences in drug use by cluster; however, Crew 450 participants who lived in Cluster 2 were significantly less likely to have used alcohol during sex than individuals in the comparison cluster (OR = 0.40; 95 % CI 0.21, 0.73) (Table 3). More significant cluster differences were found when looking at engagement in high-risk sexual behaviors. Participants who lived in Clusters 2 and 10 were significantly less likely to have had sex with a partner met on the Internet (OR = 0.36; 95 % CI 0.19, 0.69 and OR = 0.19; 95 % CI 0.04, 0.86, respectively). Additionally, individuals living in Cluster 4 were significantly more likely to have had sex with an HIV-positive partner (OR = 5.50; 95 % CI 1.17, 25.9).

Although incidence of STIs over the 12-month period ranged from 0.0 to 20.0 %, there were no significant cluster differences. Conversely, there were three clusters with significantly higher HIV prevalence than the comparison cluster: Cluster 4 (OR =

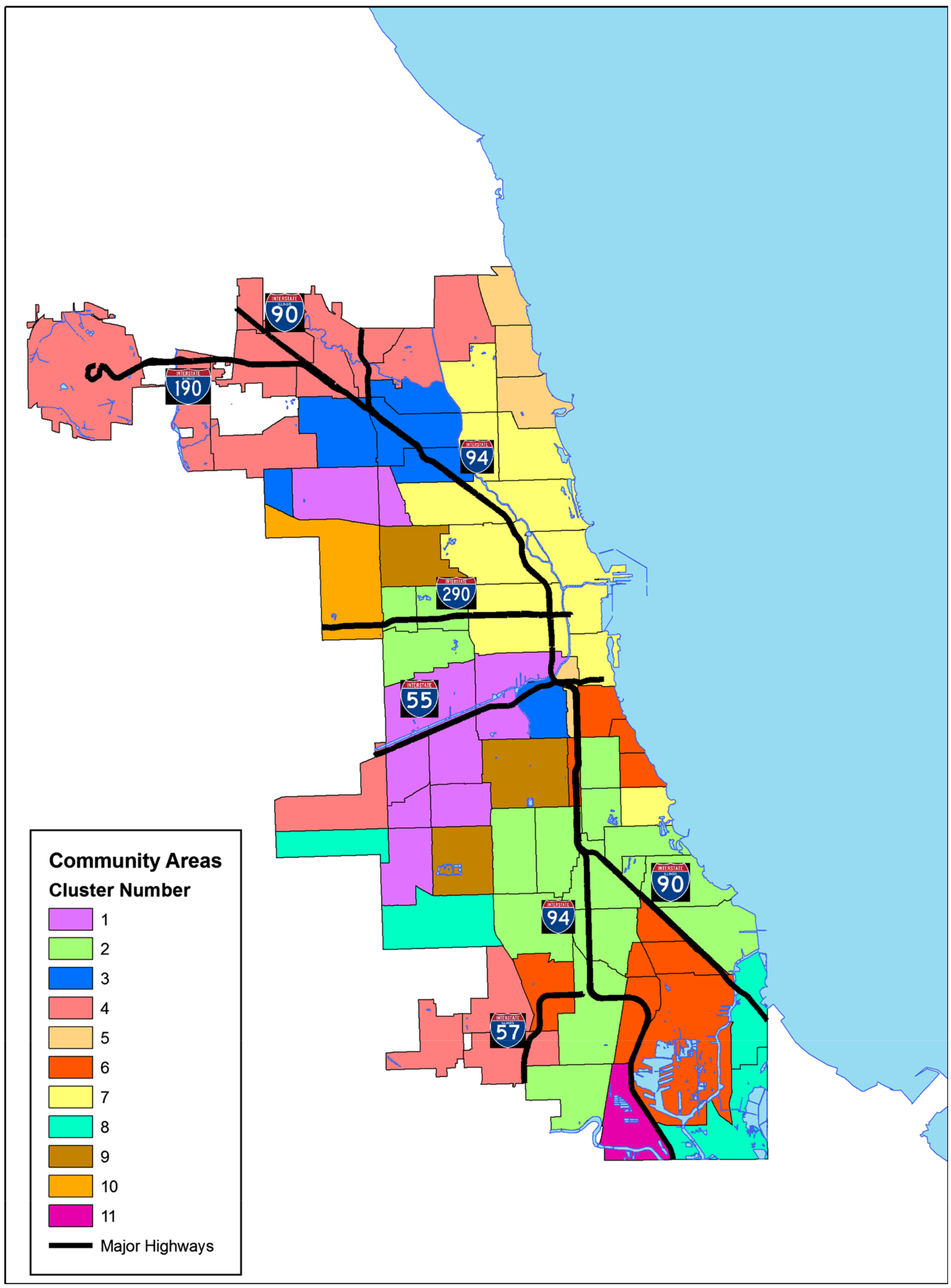

Fig. 1 Distribution of clusters within Chicago

5.50; 95 % CI 1.17, 25.9), Cluster 9 (OR = 5.50; 95 % CI 1.55, 19.5), and Cluster 2 (OR = 6.53; 95 % CI 2.33, 18.3).

Preliminary Neighborhood Cluster Comparisons to Public Health Data

Data from CDPH were used to calculate the cluster rates of HIV (among young men) and chlamydia (within entire population) (Table 3). Clusters 2 and 10 had the highest HIV incidence rate among young men (126.4 per 100,000 population and 157.8 per 100,000 population, respectively). Cluster 2 also had the highest HIV prevalence rate among young men (786.2 per 100,000 population). Chlamydia rates were similar to HIV incidence rates in that they were highest in Clusters 2 and 10.

When neighborhood-level data were compared with individual-level data, there were a few differences in HIV distribution in Chicago (Fig. 2). Although Cluster 10 had the highest HIV incidence and second highest HIV prevalence rates among young men using surveillance data, it ranked in the middle in HIV prevalence among Crew 450 participants. In addition, Cluster 4 had the lowest HIV incidence and prevalence rates among young men using neighborhood-level data but had the second highest HIV prevalence among Crew 450 participants.

Multilevel Modeling of Neighborhood Cluster on HIV Status

An unconditional model of Crew 450 participant HIV status indicated that a significant amount of variance existed between neighborhood clusters ($\chi^2 = 21.66$; $p = 0.006$), with 9.9 % of the variance occurring between clusters (Table 4). When individual-level variables were added to the model, only having an HIV-positive sex partner (OR = 6.41; CI 2.40, 17.1) and engaging in sex in exchange for money in the past 6 months (OR = 3.25; 95 % CI 1.33, 7.93) were significant predictors of HIV status. In both instances, there remained a significant amount of variance in the model for which accounting was needed. Next, cluster-level variables were added to the model. Walk Score and proportion of vacant buildings were both significantly associated with participant HIV status. Clusters with higher Walk Scores were less likely to contain HIV-positive individuals (OR = 0.94; 95 % CI 0.90, 0.98). Conversely, clusters with a larger proportion of vacant buildings were more likely to contain HIV-positive individuals (OR = 1.19; 95 % CI 1.07, 1.33). Of note, CDPH surveillance data on HIV and chlamydia rates were not significant predictors of HIV status.

Discussion

This study aids in our understanding of neighborhood-level differences in Chicago and the influences that they might have on YMSM's HIV status. Neighborhood-level factors such as SES, crime, racial distribution, and access to transportation were used to group Chicago's 77 community areas into 11 distinct clusters, and these clusters accounted for a significant amount of variance in HIV status of Crew 450 participants. As has been suggested by research among MSM in general, neighborhood-level factors

Table 2 Frequency and proportion by cluster of individual risk behaviors of Crew 450 participants in the prior 6 months ($N = 367$)

	Community area clusters										
	1 *N* (%)	2 *N* (%)	3 N (%)	4 *N* (%)	5 *N* (%)	6 *N* (%)	7[a] *N* (%)	8 *N* (%)	9 *N* (%)	10 *N* (%)	11 *N* (%)
High-risk sexual behaviors											
Condomless anal sex	14 (50.0)	40 (48.2)	11 (57.9)	11 (73.3)	18 (36.0)	7 (63.6)	55 (47.8)		20 (66.7)	7 (38.9)	
HIV-positive sex partner	3 (10.7)	4 (4.8)	1 (5.3)	3 (20.0)*	1 (2.0)	1 (9.1)	5 (4.4)		1 (3.3)	0 (0.0)	
Anonymous sex partner	0 (0.0)	5 (6.0)	3 (15.8)	0 (0.0)	2 (4.0)	0 (0.0)	13 (11.3)		2 (6.7)	0 (0.0)	
Met sex partner online	14 (50.0)	16 (19.3)**	6 (31.6)	7 (46.7)	13 (26.0)	2 (18.2)	46 (40.0)		12 (40.0)	2 (11.1)*	
Sex in exchange for money	2 (7.1)	7 (8.4)	0 (0.0)	1 (6.7)	3 (6.0)	0 (0.0)	8 (7.0)		4 (13.3)	3 (17.7)	
HIV/STI											
HIV at T1/T3	1 (3.6)	19 (22.9)***	3 (15.8)	3 (20.0)*	4 (8.0)	1 (9.1)	5 (4.4)		6 (20.0)**	2 (11.1)	
STI at T1/T3	4 (14.3)	13 (15.7)	3 (15.8)	3 (20.0)	7 (14.0)	0 (0.0)	17 (14.8)		4 (13.3)	2 (11.1)	
Drug/alcohol use											
Used "hard drugs"	10 (35.7)	12 (14.5)	8 (42.1)	3 (20.0)	17 (34.0)	1 (9.1)	30 (26.1)		6 (20.0)	3 (16.7)	
Used drugs during sex	5 (17.9)	19 (22.9)	4 (21.1)	4 (26.7)	12 (24.0)	3 (27.3)	38 (33.0)		9 (30.0)	4 (22.2)	
Used alcohol during sex	10 (35.7)	21 (25.3)*	10 (52.6)	8 (53.3)	18 (36.0)	5 (45.5)	53 (46.1)		12 (40.0)	7 (38.9)	
No. of participant observations	28	83	19	15	50	11	115	4	30	18	3

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

[a] Comparison group

Table 3 Means and SDs by cluster for HIV and chlamydia rates (per 100,000 population) as reported by the Chicago Department of Public Health

	Community area clusters																						Chicago
	1		2		3		4		5		6		7		8		9		10		11		
	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)	c	M (SD)
HIV incidence rate[a]	6.9 (17.0)		126.4 (129.3)	↑	20.0 (47.0)		1.2 (1.0)		75.6 (85.4)		1.4 (1.0)		36.1 (62.1)				91.3 (83.0)		157.8 (–)	↑			42.2 (82.3)
HIV prevalence rate[a]	39.0 (86.9)		786.2 (218.2)	↑	88.8 (142.4)		34.7 (120.1)		373.8 (270.2)		500.2 (497.8)		151.1 (168.6)				374.5 (96.4)		591.7 (–)				298.8 (368.2)
Chlamydia rate[b]	574.8 (98.1)		2347.6 (575.2)	↑	368.0 (41.4)		291.4 (265.1)		503.4 (91.6)		1637.2 (504.8)		551.5 (491.2)				1463.2 (263.9)		2280.9 (–)	↑			1069.3 (897.5)

[a] Rates for men ages 15–24 years

[b] Rates for all residents

[c] Symbol↑ = cluster mean is greater than 1 SD above the mean for all Chicago community areas

Clusters have significantly different means ($p < 0.0001$) for all neighborhood-level characteristics

also appear to play a significant role in explaining HIV transmission and infection among YMSM, above and beyond the influence of individual-level factors (Bianchi et al., 2007; Egan et al., 2011; Peterson et al., 1996).

In addition to showing that clusters vary by HIV status, this study was able to identify two neighborhood-level factors which accounted for the variance in HIV status among YMSM—Walk Score and proportion of vacant buildings. Vacant buildings are considered a physical sign of neighborhood disorder, similar to blight and litter, and often associated with social signs of neighborhood disorder such as crime and low collective efficacy—or a belief in your ability to impact your neighborhood (Garvin et al., 2013; Sampson, 2012). Interestingly, the proportion of vacant buildings was the only indicator of neighborhood disorder that was associated with HIV status; other typical neighborhood indicators of disorder associated with HIV infection, such as proportion of households living below the poverty line or number of drug arrests, were not found to account for any of the variance between clusters. This discrepancy may be due to the implications of empty and abandoned buildings within one's neighborhood, specifically the destabilization of community infrastructure as people leave their homes and businesses for economic reasons (Buitrago, 2013). Research has identified ties between lack of stability in housing and employment and engagement in HIV risk behaviors (German & Latkin, 2012); therefore, it is plausible that a general feeling of instability caused by the deterioration of one's community could result in a similar level of high-risk behavior (Bowleg et al., 2014; Wallace & Wallace, 1998).

There was an inverse association between Walk Score and individual HIV status—YMSM who lived in clusters with higher Walk Scores (i.e., more walkable neighborhoods) were less likely to be HIV-positive. The fact that this was found to be one of the only neighborhood-level variables to explain the variance between clusters highlights the importance of social and physical isolation in determining engagement in HIV risk behaviors. Individuals who are isolated to a single community area in Chicago are likely to have a much smaller and much denser sexual network than individuals who freely travel throughout the city (Doherty, Padian, Marlow, & Aral, 2005). Additionally, the clusters with the lowest Walk Scores also tend to be ones with the largest proportion of Black residents, which highlights the significant racial segregation within Chicago. Due to the high prevalence of HIV among Black YMSM, inclusion in these dense and racially homophilous sexual networks places Black YMSM at a heightened risk for HIV acquisition (Van Tieu et al., 2015). Another factor to consider is access to health care services; research has shown that people who live in impoverished and isolated areas have fewer health care resources available to them than those in wealthier and more accessible areas of the U.S. (Moses et al., 2013). Thus, difficulty in accessing medical services, particularly sexual health resources, might lead to an increase in untreated STIs and facilitate the spread of STIs and HIV. These

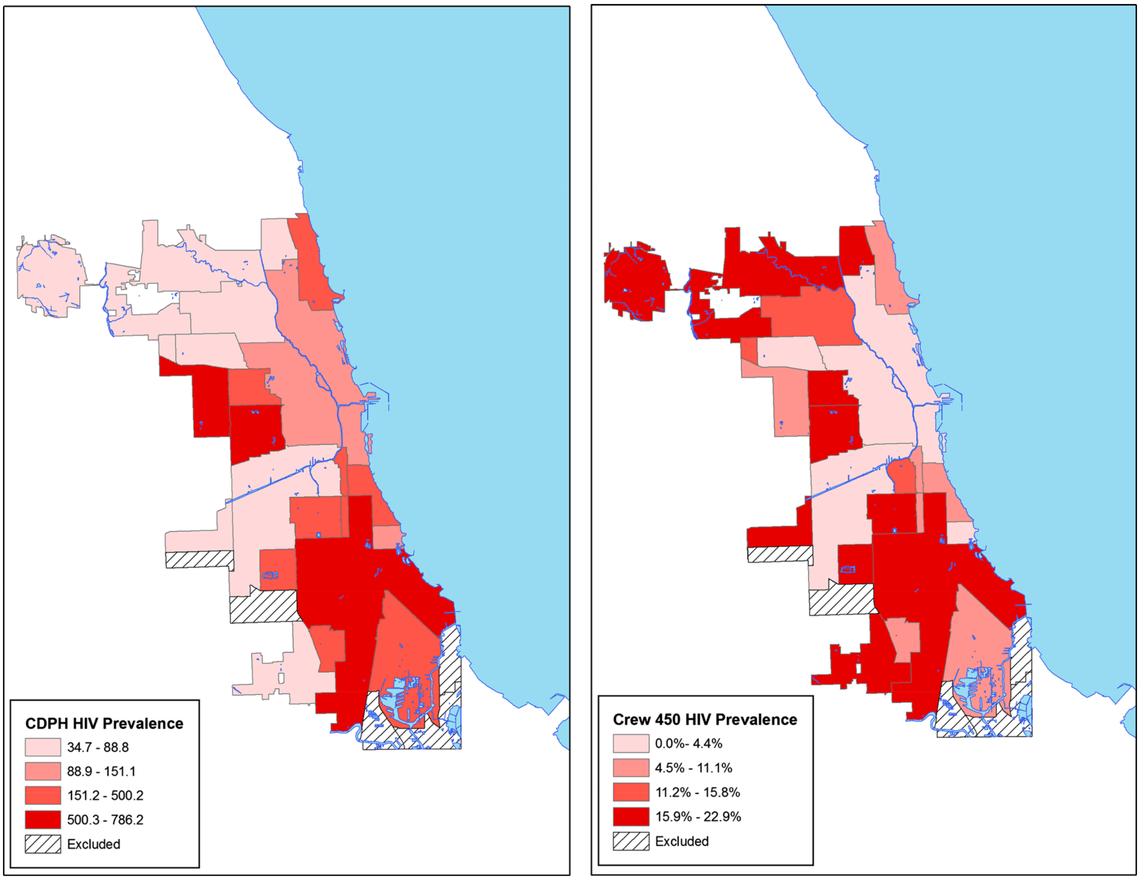

Fig. 2 HIV prevalence within Chicago by cluster: CDPH surveillance data (2009–2010) for men aged 15–24 years versus YMSM within Crew 450

issues are additionally challenging to YMSM, who are frequently reliant on their parents/caregivers for transportation, health care insurance, and money.

Since YMSM in Clusters 2 and 9 were not engaging in any more high-risk behaviors than YMSM in Cluster 7, this lends credence to the belief that neighborhood-level factors also play a role in explaining HIV prevalence. Prior research has found that HIV infection is highly correlated with poverty and crime, and that it has disproportionately impacted the Black community (Bauermeister, Zimmerman, & Caldwell, 2011; Denning, DiNenno, & Wiegand, 2011); these variables are all key factors in Cluster 2 and may confer risks on residents in ways that were not measured in this study. Similarly, high levels of drug use and low education are also known to be associated with HIV infection (Latkin, Williams, Wang, & Curry, 2005) and might contribute to the high HIV prevalence in Cluster 9, which is characterized by a high number of drug arrests. YMSM living in this cluster did not demonstrate higher rates of drug use but might still be at greater risk for HIV infection due to characteristics of other residents in their neighborhood: if an individual is more likely to have sex with someone in his neighborhood, and men living in his neighborhood are more likely to use drugs (especially injection drugs); they are more likely to engage in sex with a man who has HIV.

In addition to the main findings, this article also highlights interesting descriptive points such as the two clusters with the greatest number of drug arrests—Clusters 9 and 10—did not have the highest proportion of YMSM who used "hard drugs." Nearly one-half of drug arrests in the United States are for possession of marijuana (Federal Bureau of Investigation, 2010); since we excluded marijuana use from classifying an individual as having used "hard drugs," this might explain the discrepancy. It is also possible that YMSM may not be arrested for drugs in the same way as the general population; for example, their drug use may be less likely to occur in areas regularly patrolled by the police.

Finally, there are clear differences between cohort and surveillance HIV prevalence when comparing clusters in Chicago, and CDPH data were not significant neighborhood-level predictors of individual HIV status. Living in a neighborhood with a high HIV prevalence does not seem to increase one's likelihood for becoming HIV infected, at least within this sample of YMSM. There are a number of potential explanations for this phenomenon. If these YMSM are aware of the high HIV prevalence in their community, they might either seek sexual partners from a different area of the city or be more insistent on condom use with partners from their neighborhood. It is also possible that the differences reflect the methodological effects of cohort data versus public health case report data. Surveillance data come predomi-

Table 4 Means and SDs by cluster for individual- and neighborhood-level characteristics

	Odds ratio	*p* value	Tau	Variance between clusters (%)	Variance components	
					χ^2	*p* value
Unconditional model	–	–	0.36	9.86	21.66	0.006
Individual-level models						
High-risk sexual behaviors						
Condomless anal sex	1.07	0.84	0.36	9.86	21.55	0.006
HIV-positive sex partner	6.41	<0.001	0.41	11.08	23.11	0.004
Anonymous sex partner	0.70	0.61	0.36	9.86	21.58	0.006
Met sex partner online	1.19	0.61	0.37	10.11	22.30	0.005
Sex in exchange for money	3.25	0.01	0.41	11.08	20.79	0.008
STI at T1/T3	0.92	0.85	0.36	9.86	21.71	0.006
Drug/alcohol use						
Used drugs	0.77	0.49	0.35	9.62	20.90	0.008
Used drugs during sex	0.98	0.96	0.36	9.86	21.64	0.006
Used alcohol during sex	0.71	0.30	0.35	9.62	20.69	0.008
Cluster-level models						
Neighborhood characteristics						
% Black[a]	1.01	0.14	0.19	5.46	11.49	0.118
% Hispanic[a]	0.99	0.60	0.41	11.08	20.27	0.005
Ethnic heterogeneity[a]	0.36	0.45	0.34	9.37		
% Male[a]	0.86	0.20	0.25	7.06	12.94	0.073
% >65 years[a]	1.07	0.51	0.36	9.86	18.56	0.010
% <HS edu.[b]	1.01	0.69	0.39	10.60	19.92	0.006
% Living in poverty[b]	1.04	0.25	0.22	6.27	12.92	0.074
% Moved in last year[b]	0.94	0.27	0.31	8.61	18.34	0.011
% Single-parent households[b]	1.02	0.07	0.11	3.24	10.72	0.151
% Foreign-born[b]	0.98	0.35	0.33	9.12	16.40	0.022
% Same-sex households[b]	0.98	0.46	0.37	10.11	18.68	0.009
# Violent crimes[c]	1.00	0.53	0.36	9.86	18.91	0.009
# Drug arrests[c]	1.00	0.62	0.38	10.35	20.10	0.006
Transit score[d]	0.94	0.09	0.19	5.46	12.53	0.084
Walk score[d]	0.94	0.01	0.01	0.03	6.54	>0.500
% Vacant buildings[e]	1.19	0.01	0.00	0.00	9.35	0.228
Chicago Department of Public Health Data						
HIV incidence rate[f]	1.00	0.73	0.41	11.08	19.67	0.007
HIV prevalence rate[f]	1.00	0.87	0.43	11.56	21.96	0.003
Chlamydia rate[g]	1.00	0.12	0.16	4.64	11.06	0.135

[a] Data from 2010 United States Census

[b] Data from 2008 to 2012 American Community Survey

[c] Data from Chicago Police Department

[d] Data from http://www.walkscore.com

[e] Data from Woodstock Institute

[f] Data from Chicago Department of Public Health—rates for men ages 15–24 years

[g] Data from Chicago Department of Public Health—rates for all residents

nantly from doctors' offices, hospitals, and other medical clinics, so individuals who do not regularly access health care might be missed through these means. However, cohort data are not necessarily reliant on contact with medical services and thus might include people who are averse to going to a clinic. Conversely, individuals who willingly visit their doctor might not want to take part in a research study. Although there is likely significant overlap in people identified by either method, surveillance data and cohort data each might include a subset of the population missed by the other method, which could be reflected here.

This study has several limitations. Several neighborhood-level factors that could be influential in predicting engagement in risk behaviors and HIV infection, such as density of bars and clubs, were not publicly available and were thus not able to be included in the cluster analysis. Two clusters had fewer than five Crew 450 participants residing in them and were therefore dropped from the subsequent analysis; although comparisons could be made among the remaining 8 clusters, we could not identify significant differences in Crew 450 data for Clusters 8 and 11 due to the small sample size. In addition, the frequency counts in most cells (within clusters) were quite small, and thus, percentages of important behaviors such as "hard drug" use and sexual risk behavior, as well as HIV and STI cases should be considered preliminary and in need of further study and replication. Geographical location was not included in the cluster analysis, although it could play a key role in determining neighborhood-level characteristics. However, despite this omission, most community areas within each cluster were still adjacent to each other or had a common position (for example, the community areas comprising Cluster 4 are all located on the western outskirts of the city). All individual-level data except HIV/STI test results were reliant on self-report and open to several biases. However, social desirability bias was minimized through the use of CASI technology, and time-anchoring questions assisted with difficulties in recalling behaviors.

Conclusion

In order to fully understand the spread of HIV among YMSM, we need to look beyond individual-level factors as predictors. Using a clustering approach to group community areas in Chicago together by commonalities resulted in the ability to identify neighborhood-level correlates of HIV infection and high-risk behaviors among YMSM. While two individual-level factors were shown to be associated with HIV infection within Crew 450 participants, a significant amount of neighborhood-level variance remained, and Walk Score and proportion of vacant buildings accounted for this variance.

Future research among YMSM needs to investigate the mechanisms by which neighborhood of residence might influence their engagement in risk behaviors or acquisition of HIV. For instance, is it the lack of health care resources or social isolation driving HIV infection, or is it another unidentified factor? And do YMSM living in high-risk neighborhoods preferentially seek partners from lower risk neighborhoods, or are they more likely to use condoms when having sex with a partner from their same neighborhood? By better understanding the ways in which neighborhood-level factors affect HIV transmission among YMSM, researchers can either develop community-level interventions to address overarching issues, such as isolation, or can better tailor extant interventions to target individuals at greatest risk for HIV infection, specifically YMSM.

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