



Mortgage Discrimination and Racial/Ethnic Concentration Are Associated with Same-Race/Ethnicity Partnering among People Who Inject Drugs in 19 US Cities

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Abstract Racial/ethnic homophily in sexual partnerships (partners share the same race/ethnicity) has been associated with racial/ethnic disparities in HIV. Structural racism may partly determine racial/ethnic homophily in sexual partnerships. This study estimated associations of racial/ethnic concentration and mortgage discrimination against Black and Latino residents with racial/ethnic homophily in sexual partnerships among 7847 people who inject drugs (PWID) recruited from 19 US cities to participate in CDC’s National HIV Behavioral Surveillance. Racial/ethnic concentration was defined by two measures that respectively compared ZIP code-level concentrations of Black residents to White residents and Latino residents to White residents, using the Index of Concentration at the Extremes. Mortgage discrimination was defined by two measures that respectively compared county-level mortgage loan denial among Black applicants to White applicants and mortgage loan denial among Latino applicants to White applicants, with similar characteristics (e.g., income, loan amount). Multilevel logistic regression models were used to estimate associations. Interactions of race/ethnicity with measures of racial/ethnic concentration and mortgage discrimination were added to the final multivariable model and decomposed into race/ethnicity-specific estimates. In the final multivariable model, among Black PWID, living in ZIP codes with higher concentrations of Black vs. White residents and counties with higher mortgage discrimination against Black residents was associated with higher odds of homophily. Living in counties with higher mortgage

discrimination against Latino residents was associated with lower odds of homophily among Black PWID. Among Latino PWID, living in ZIP codes with higher concentrations of Latino vs. White residents and counties with higher mortgage discrimination against Latino residents was associated with higher odds of homophily. Living in counties with higher mortgage discrimination against Black residents was associated with lower odds of homophily among Latino PWID. Among White PWID, living in ZIP codes with higher concentrations of Black or Latino residents vs. White residents was associated with lower odds of homophily, but living in counties with higher mortgage discrimination against Black residents was associated with higher odds of homophily. Racial/ethnic segregation may partly drive same race/ethnicity sexual partnering among PWID. Future empirical evidence linking these associations directly or indirectly (via place-level mediators) to HIV/STI transmission will determine how eliminating discriminatory housing policies impact HIV/STI transmission.

Keywords Discrimination · HIV · Racial/ethnic disparities · People who inject drugs · Segregation · Sexual partnerships

Introduction

The increase in opioid use across all racial/ethnic groups in the USA raises concerns about persistent racial/ethnic disparities in HIV infection, as Black and Latino people who inject drugs (PWID) continue to have higher HIV diagnosis rates than White PWID [1–4]. With the exception of one recent study documenting that Black women who inject drugs report higher prevalence of HIV risk behaviors, including condomless sex with non-primary partners, transactional sex, and multiple partners, than their Black male and White male and female counterparts [5], most studies to date suggest that racial/ethnic differences in risk behaviors, including sharing injection equipment and condomless sex, do not explain racial/ethnic disparities in HIV among PWID [6, 7]. Specifically, despite having higher prevalence of HIV infection, overall Black PWID have been documented to share injection equipment and engage in sexual risk behaviors at lower rates than other racial/ethnic groups of PWID [3, 4, 7–9].

A growing line of evidence points to sexual network and partnering dynamics as strong determinants of racial/ethnic disparities in HIV. Specifically, two dominant explanations have upheld this hypothesis. First, corresponding with higher rates of HIV in their communities, Black and Latino PWID are documented to have higher percentages of HIV-positive sexual and injection network members in their social networks than White PWID [6, 7, 9–12]. Second, Black and White PWID select sexual and injection network members of the same racial/ethnic group at higher percentages than their Latino counterparts [7, 9, 11]. Mathematical models suggest that such partnering patterns by race/ethnicity perpetuates racial/ethnic disparities in HIV infection among Black and White PWID, with Latino PWID serving as a potential “bridging group” [6, 7, 9, 11].

Personal preferences, perceptions of familiarity and trust, and racist attitudes have been documented to influence racial/ethnic homophily in sexual partnerships in the general population [13–15], but geographic and structural factors may also determine partner selection [16–20]. The US legacy of systematic spatial segregation of racial/ethnic groups by policies and procedures that cause people of color in the USA to be discriminated against in the housing market may also contribute to partnering patterns by directly determining the likelihood that people of different racial/ethnic backgrounds interact.

Discriminatory housing practices which originated with Jim Crow laws were reinforced with the Hoover administration’s redlining policies that established restrictive residential zoning according to race and encouraged mortgage lenders and real estate agents to deny loans and restrict racial/ethnic minorities from leasing and purchasing homes in specific neighborhoods [21]. Despite enactment of policies, including the Fair Housing Act, Equal Credit Opportunity Act, and Community Reinvestment Act, which have collectively sought to prohibit redlining and racial/ethnic disparities in leasing and mortgage lending [22], Black and Latino people continue to be denied mortgages and leases and are more likely to face unfavorable terms in mortgage lending and rental agreements than their White counterparts [22].

Such contemporary forms of housing discrimination perpetuate the establishment of separate and unequal Black, Latino, and White communities [23, 24]. Independent of household income, on average, White households are located in

neighborhoods where 80% of households are White. Black and Hispanic/Latino households are located in neighborhoods where less than 50% of households are White [25], and segregated predominantly Black and Latino communities are on average characterized as having less economic and educational resources and being more vulnerable to disinvestment, depopulation, substandard housing, growth of informal economies (e.g., drug market activity), and disenfranchisement and political disempowerment, than predominantly White communities [22, 25–28].

The impacts of racial/ethnic residential segregation on health, including HIV- and STI-related outcomes and behaviors, are inconsistent and may partly relate to the type and magnitude of resources provided within a racially or ethnically segregated community. As posited by the ethnic density hypothesis [29], concentration of non-White racial/ethnic groups may facilitate better health behaviors and outcomes among members of these groups by increasing access to positive social capital, strengthening cultural pride, and increasing resilience and resistance to discrimination and prejudice from White people. Additionally, concentration of residents of the same racial/ethnic group may reinforce norms around health-protective behaviors for some racial/ethnic groups [29, 30]. Indeed, research by Momplaisir and colleagues documents that racially segregated networks among Black PWID are associated with lower odds of syringe sharing than racially segregated networks among White and Hispanic/Latino PWID [9].

The potential for racial/ethnic residential segregation to bear negative HIV/STI-related consequences for Black populations and other racial/ethnic groups has also been documented. Among Black people in particular, residence in racially segregated localities has been associated with sexual risk behaviors (e.g., large number of partners, condomless sex) and HIV [18, 31–38]. The mechanisms behind these relationships have frequently been described as manifestations of the ways discriminatory housing market forces restrict Black residents to neighborhoods vulnerable to factors that impede economic mobility and health (i.e., economic disinvestment, depopulation, crime, intensified policing strategies, etc. [26, 39–41]).

Although less documented among Hispanic/Latino populations, residential segregation has been associated with suboptimal health outcomes not specific to HIV/STIs, including physical inactivity, poor birth outcomes, and self-rated health [42, 43]. Similar mechanisms as

those proposed for the “residential segregation-health adversity” relationship among Black residents have been proposed for Hispanic/Latino residents. The strength of the relationship has been suggested to be influenced by place of origin and nativity, however. For example, prior studies suggest residential segregation is associated with more health problems among Puerto Ricans than Mexican Americans [30], and that exposure to “US-born Hispanic/Latino enclaves” is more health adverse than exposure to “foreign-born Hispanic/Latino enclaves” [42, 43]. Differences in healthcare utilization, ethnic supports, and solidarity have been posited to influence these findings [30, 42].

Collectively, prior literature suggests residential segregation may impact the burden of HIV/STIs and other health outcomes among people of color in multiple ways. Several studies hypothesize that patterns of sexual partnering by race/ethnicity may be mediators of the relationship between residential segregation and HIV, but no study to date has explored whether residential segregation is associated with racial/ethnic homophily in sexual partnerships. This cross-sectional analysis fills gaps in knowledge on the potential influence of residential segregation on racial/ethnic homophily in sexual partnerships, by exploring whether ZIP code-level racial/ethnic concentration and county-level mortgage discrimination—a measure of institutional racism less studied to date—influence racial/ethnic homophily in sexual partnerships among PWID. Given the cross-sectional design of the study and lack of temporal order in mortgage discrimination and racial/ethnic concentration, we consider these measures as potential covariates rather than respective precedents and consequents of each other.

Material and Methods

Data Collection and Sampling

This analysis has a cross-sectional multilevel design. Individual-level data gathered from PWID enrolled in the 2012 cycle of the Center for Disease Control and Prevention’s National HIV Behavioral Surveillance (NHBS) was linked to ZIP code-level data from the 2008–2012 US Census Bureau’s 5-year American Community Survey (ACS) and county-level data from the 2012 Housing Mortgage Disclosure Act database. ACS 5-year estimates aggregate survey values across a 5-year

time frame and have a larger sampling frame and greater reliability than 1-year estimates. ACS 1-year estimates are also not available at the ZIP code level, whereas 5-year estimates are available at the ZIP code level [44].

A total of 12,425 PWID recruited from 20 metropolitan statistical areas with high AIDS prevalence in 2006 were eligible for the 2012 NHBS cycle. Details on NHBS recruitment can be found elsewhere [45, 46]. PWID were recruited by respondent-driven sampling. Participants were eligible if they were ≥ 18 years, reported injection drug use in the past year, demonstrated evidence of injection (e.g., track marks), resided in an NHBS-eligible metropolitan statistical area, and provided oral consent [47]. Once enrolled, PWID completed anonymous questionnaires collecting self-reported information on HIV-related risk behaviors, HIV testing, and the use of prevention and harm reduction services. Anonymous HIV testing was also offered to all eligible participants as part of the NHBS study.

The San Juan-Bayamon site was excluded from analysis because the sample lacked racial/ethnic diversity. Among those who were eligible in all other NHBS sites, 9195 Hispanic/Latino, non-Hispanic/Latino Black, and non-Hispanic/Latino White PWID (hereafter referred to as Latino, Black, and White PWID) who had valid/and complete surveys, valid ZIP code information, and were male or female (transgender persons had a small sample size ($n = 70$)) were retained. Participants were excluded from this restricted sample if they reported no sexual intercourse in the past year ($n = 1273$) or were missing information on key covariates ($n = 5$). The final analytic sample included 7847 participants. Participant characteristics were similar among the analytic and full samples.

Measures

Using standardized questionnaires, trained interviewers collected self-reported participant information, including residential county and ZIP code information and perceived characteristics of the last sexual partner in the past year (male partners among women; male and female partners among men). Participants were assigned to metropolitan statistical areas and regions based on interview site. Those who lived in ZIP codes that crossed county lines were assigned to the county where most participants living in that ZIP code reported residing ($< 3\%$ of the eligible sample). When possible, participants who reported current homelessness were

assigned to the ZIP code in which they reported frequently sleeping. Homeless persons were included in the analytic sample based on the assumption that their social interactions are influenced by discriminatory housing practices and racial/ethnic composition of the broader communities they seek and find shelter.

The outcome was racial/ethnic homophily of last sexual partner (hereafter referred to as homophily) defined as the last (vaginal or anal) sexual partner in the past 12 months who belonged to the same racial/ethnic group as the participant. For example, among Black PWID, the reference category “0” denoted partners who were not Black, and “1” denoted Black sexual partners. Five hundred and seventeen men reported both a recent male partner and recent female partner in the past 12 months. The majority ($\sim 70\%$) reported high concordance in whether these male and female sex partners were of the same race/ethnicity as the participant. Therefore these men were coded as being in a same-race/ethnicity partnership if at least one partner (e.g., the last male and/or female partner) was reported to be the same race/ethnicity as the participant.

Primary exposures included two measures of ZIP code-level racial/ethnic concentration and two measures of county-level racial/ethnic mortgage discrimination. The two ZIP code-level measures of racial/ethnic concentration were separately calculated to compare concentrations of Black or Latino residents to White residents using the Index of Concentration at the Extremes (ICE) [48–51]. ZIP code-level data on race/ethnicity came from the 2010–2014 US Census Bureau American Community Survey (ACS).

$$\text{ICE} = (A_i - P_i) / T_i$$

Here A is the number of Black (or Latino) residents in ZIP code i ; P is the number of White residents in ZIP code i ; and T is the total number of residents with information on race and ethnicity in ZIP code i . ICE ranges from -1 to 1 , with -1 denoting 100% of White residents and 1 denoting 100% of Black or Latino residents in ZIP codes. An increase in ICE reflects an increase in Black or Latino residents as compared to White residents.

County-level mortgage discrimination measures were defined using methods pioneered by Gee [52, 53]. Specifically, data from the 2012 Housing Mortgage Disclosure Act database of the Federal Reserve Board was used to separately determine the odds of mortgage

loan denial among Black or Hispanic/Latino residents as compared to White residents at the county level, controlling for sex, log of gross annual income, and log of loan amount. Two measures of housing loan denial were calculated accordingly: mortgage discrimination against Black residents, which compared mortgage loan denial among Black residents (coded “1”) to White residents (coded “0”), and mortgage discrimination against Latino residents, which compared mortgage loan denial among Latino residents (coded “1”) to White residents (coded “0”). Because the odds of both mortgage discrimination measures could not be zero, both measures were centered at one to aid interpretation of interactions.

Covariates included region (North, South, Midwest, West) and the following participant characteristics: age, gender, race/ethnicity, annual income (i.e., earning 10,000 USD or more), high school or general equivalency diploma, and full-time employment. Additional covariates included the following behaviors measured within a 12-month reporting period: incarceration (i.e., held in a jail or prison for at least 1 day), homelessness (i.e., self-reported homelessness or residing on the street, in a shelter, in a single room occupancy hotel, or in a car, or temporarily residing with friends or relatives at any time), daily injection drug use, binge drinking, any non-injection drug use, and exchange sex. For descriptive purposes, we also considered HIV status of the participant and characteristics of the last sexual partnership, such as duration of partnership (measured in days), type of partnership (i.e., partnership with a main or casual sex partner), and whether a given participant had condomless sex with the last sexual partner in the past 12 months.

Statistical Analysis

The distributions of all participant characteristics, place characteristics, and characteristics of the last sexual partner were determined, and correlations among county and ZIP code-level measures were assessed. Three series of multilevel logistic regression models, which included random intercepts at ZIP code, county, and MSA levels, were used to estimate the associations of participant characteristics and measures of ZIP code-level racial/ethnic concentration and county-level mortgage discrimination with racial/ethnic homophily in sexual partnerships of PWID.

First, univariate models estimating associations of participant characteristics, each measure of ZIP code-level racial/ethnic concentration, and each measure of

county-level mortgage discrimination with homophily were analyzed. Second, if participant race/ethnicity and/or measures of racial/ethnic concentration or mortgage discrimination were significant in univariate models, we then explored potential racial/ethnic differences in associations by adding interaction terms of the product of race/ethnicity with each measure of racial/ethnic concentration and each measure of mortgage discrimination. The reference group for all interactions was White PWID. Therefore, a significant interaction term of the product of Black race with any measure of racial/ethnic concentration or mortgage discrimination suggested the association between a given measure of racial/ethnic concentration or mortgage discrimination and homophily among Black PWID differed from that of White PWID. Similarly, a significant interaction term of the product of Latino ethnicity with any measure of racial/ethnic concentration or mortgage discrimination among Latino PWID suggested the association between a given measure of racial/ethnic concentration or mortgage discrimination and homophily differed from that of White PWID.

Third, we analyzed two multivariable models estimating the associations of each measure of racial/ethnic concentration and mortgage discrimination with homophily while controlling for geographic region and participant characteristics. The first multivariable model excluded interaction terms of PWID race/ethnicity with measures of racial/ethnic concentration and mortgage discrimination. The second multivariable model included interactions of race/ethnicity with measures of mortgage discrimination and racial/ethnic concentration that were significant in preliminary interaction models.

In the fourth and final step, we decomposed the interactions evaluated in the second multivariable model into race/ethnicity-specific associations using post-estimation procedures. Standardized odds ratios are presented. Analysis was conducted using Stata version 13 (StataCorp LP, College Station, TX).

Results

Participant Characteristics

The majority of participants were Black (48%), followed by White (30%) and Latino (21%) (Table 1). Among Latino participants reporting ancestry, most were Puerto

Table 1 Distributions of ZIP code, county, and participant characteristics among 7847 people who inject drugs living in 19 US cities in 2012

Characteristics	<i>N</i> (%) or median (IQR)
Participant characteristics	
Current age, median (IQR)	45.41 (37–54)
Male	5669 (72.24)
Race/ethnicity ¹	
Latino	1661 (21.17)
Black	3798 (48.40)
White	2388 (30.43)
Annual income (< 10,000 USD)	4481 (57.10)
High school/general equivalency diploma	5204 (66.32)
Full-time employment	324 (4.13)
Incarceration, past 12 months	2855 (36.38)
Homelessness, past 12 months	4426 (56.40)
Positive NHBS HIV test result ²	665 (8.57)
Drug use and sexual behaviors	
Daily injection drug use, past 12 months	5634 (71.80)
Non-injection drug use, past 12 months	5837 (74.39)
Binge drinking, past 12 months	4730 (60.28)
Sex exchange, past 12 months	3640 (46.39)
Characteristics of sexual partnerships	
Number of sexual partners ³ , past 12 months, median (IQR)	2 (1–5)
Same-race/ethnicity sexual partner, past 12 months	5937 (75.66)
Characteristics of last same-sex male partner	
Main partner	134 (17.80)
Length of relationship (days), median (IQR)	120 (1–730)
Condomless anal sex, past 12 months	344 (46.24)
Characteristics of last female heterosexual partner	
Main partner	3020 (55.56)
Length of relationship (days), median (IQR)	730 (150–2555)
Condomless anal or vaginal sex, past 12 months	3993 (73.50)
Characteristics of last male heterosexual partner	
Main partner	1421 (65.27)
Length of relationship (days), median (IQR)	1095 (180–2555)
Condomless anal or vaginal sex, past 12 months	1630 (75.08)
Region⁴ and place characteristics	
Northeast	1898 (24.19)
South	3171 (40.41)
Midwest	635 (8.09)
West	2143 (27.31)
ZIP code (<i>N</i> = 889)	
Concentrations of Black vs. White residents, median (IQR)	0.11 (–0.26–0.52)
Concentrations of Latino vs. White residents, median (IQR)	–0.06 (–0.26–0.26)
County (<i>N</i> = 53)	
Mortgage discrimination against Black residents, median (IQR)	2.01 (1.84–2.16)
Mortgage discrimination against Latino residents, median (IQR)	1.48 (1.39–1.52)

¹ Latino can be of any race; Black and White are non-Hispanic/Latino.

² The denominator excludes participants who did not consent to NHBS HIV testing, had an invalid or unknown test result, or self-reported positive but received a negative NHBS HIV test result.

³ The mean number of sexual partners was calculated among female and male sexual partners for men and male sexual partners for women.

⁴ The Northeast region includes the MSAs of Boston, Massachusetts; Nassau-Suffolk, New York; New York, New York; Newark, New Jersey; and Philadelphia, Pennsylvania. South region includes Atlanta, Georgia; Baltimore, Maryland; Dallas, Texas; Houston, Texas; Miami, Florida; New Orleans, Louisiana; and District of Columbia. Midwest region includes Chicago, Illinois and Detroit, Michigan. West region includes Denver, Colorado; Los Angeles, California; San Diego, California; San Francisco, California; and Seattle, Washington.

Rican (47%) and Mexican (37%); the remaining were Cuban, Dominican, or reported “other” countries of origin (data not shown). Most participants were male (72%), middle-aged (median = 45 years; interquartile range (IQR) = 37–54 years), and reported low economic status (4% employed full-time; 57% earned < US\$10,000 annually). More than half reported engaging in daily injection drug use, binge drinking, or non-injection drug use (60–74%) in the past 12 months, and many experienced incarceration (36%) or homelessness (56%) in the past 12 months. Most participants who enrolled in the NHBS study were recruited from the South (40%), followed by the West (27%), Northeast (24%) and Midwest (8%).

Participants reported a median of 2 sexual partners (IQR = 1–5) in the past 12 months. Most participants who reported their last sexual partner was the opposite sex indicated that partner was a main partner (women = 65%; men = 56%). Most participants reporting that their last sexual partner was the opposite sex reported knowing this partner for 2 years or more, and a large proportion (~75%) reported having unprotected anal or vaginal sex in the past 12 months with this partner. Only 18% of men who reported their last sexual partner was the same sex indicated that partner was a main partner. The median duration of relationships with same-sex partners was 120 days among men, and less than half reported condomless anal sex with these same-sex partners. Homophily in sexual partnerships was common overall (76%) but highest among Black (85%), followed by White (71%) and Latino PWID (61%).

Approximately, 9% of PWID who consented to test for HIV as part of the NHBS study tested positive. The percentage of PWID who tested positive as part of the NHBS study was higher among Black PWID (12%) as compared to Latino (6%) and White PWID (5%).

ZIP Code-Level Racial/Ethnic Concentration

Overall, the median index of concentration of Black vs. White residents in ZIP codes where PWID resided was

0.11 (IQR = -0.26-0.52); and the median index of concentration of Latino vs. White residents was -0.06 (IQR = -0.26-0.26; Table 1). On average within ZIP codes that scored at or above the median ZIP code-level index of concentration of Black vs. White residents, the median percentages of Black, White, and Latino residents were, respectively, 63%, 7%, and 9%. Within ZIP codes that scored at or above the median ZIP code-level index of concentration of Latino vs. White residents, the median percentages of Black, White, and Latino residents were, respectively, 40%, 10%, and 41%. Concentration of Black vs. White residents was moderately correlated with concentrations of Latino vs. White residents ($r = 0.43$).

County-Level Mortgage Discrimination

Nearly half of PWID resided in counties where Black residents were 2 times as likely (IQR = 1.84-2.16) to not receive a mortgage loan as compared to White residents of similar applicant characteristics, and Latino residents were nearly 1.5 times as likely (IQR = 1.39-1.52) to not receive a mortgage loan as compared to White residents of similar characteristics (Table 1). Exposure to county-level mortgage discrimination did not vary considerably by PWID race/ethnicity (data not shown). County-level mortgage discrimination against Black residents was correlated with county-level mortgage discrimination against Latino residents at a value of $r = 0.74$. All other pair-wise correlations were weak ($r < 0.30$).

Univariate Models

In univariate models, as compared to White PWID (Table 2), Black PWID were significantly more likely to report homophily (OR = 1.57, CI = 1.35, 1.83), and Latino PWID were significantly less likely to report homophily (OR = 0.59, CI = 0.51,

Table 2 Univariate models estimating associations of participant characteristics, ZIP code-level racial/ethnic concentration, and county-level mortgage discrimination with racial/ethnichomophily in sexual partnerships among people who inject drugs ($n = 7847$) living in 19 US cities in 2012

	Odds ratio ⁵ (95% CI)
Participant characteristics	
Current age	1.14 (1.08, 1.21)*
Female	0.81 (0.72, 0.92)*
Race/ethnicity	
White (reference)	1.00
Black	1.57 (1.35, 1.83)*
Latino	0.59 (0.51, 0.69)*
Annual income	0.97 (0.92, 1.02)
High school/general equivalency diploma	0.94 (0.83, 1.05)
Full-time employment	0.83 (0.64, 1.07)
Incarceration, past 12 months	0.88 (0.78, 0.98)*
Homelessness, past 12 months	0.74 (0.66, 0.83)*
Drug use and sexual behaviors	
Daily injection, past 12 months	1.02 (0.90, 1.16)
Binge drinking, past 12 months	0.90 (0.80, 1.01)
Non-injection drug use, past 12 months	0.87 (0.76, 1.00)*
Sex exchange, past 12 months	0.69 (0.62, 0.77)*
Region and place characteristics	
Northeast (reference)	1.00
South	2.41 (1.45, 3.99)*
Midwest	2.05 (0.95, 4.40)
West	0.78 (0.46, 1.34)
ZIP code ($N = 889$)	
Concentration of Black vs. White residents	1.17 (1.08, 1.27)*
Concentration of Latino vs. White residents	1.04 (0.96, 1.12)
County ($N = 53$)	
Mortgage discrimination against Black residents	1.00 (0.81, 1.22)
Mortgage discrimination against Latino residents	0.95 (0.75, 1.20)

⁵ Standardized odds ratios are presented. Asterisk denotes $p < 0.05$

0.69). Associations of other participant characteristics with homophily are presented in Table 2. PWID recruited from the South were more likely to report racial/ethnic homophily as compared to PWID in the Northeast (OR = 2.41, CI = 1.45, 3.99). ZIP code-level concentrations of Black vs. White residents were significantly associated with homophily among PWID (OR = 1.17, CI = 1.08, 1.27). ZIP code-level concentrations of Latino vs. White residents were not significantly associated with homophily (OR = 1.04, CI = 0.96, 1.12). No measure of county-level mortgage discrimination was significantly associated with homophily among PWID (mortgage discrimination

against Black residents, OR = 1.00, CI = 0.81, 1.22; mortgage discrimination against Latino residents, OR = 0.95, CI = 0.75, 1.20).

Preliminary Interaction Models

ZIP Code-Level Racial/Ethnic Concentration

In preliminary interaction models (Table 3), both interaction terms of PWID race/ethnicity with ZIP code-level concentrations of Black vs. White residents were statistically significant (Black PWID/White PWID, AOR = 3.17, CI = 2.71, 3.71; Latino

Table 3 Models estimating racial/ethnic differences⁶ in associations of ZIP code-level racial/ethnic concentration and county-level mortgage discrimination with racial/ethnic homophily in sexual partnerships among people who inject drugs (n = 7847) living in 19 US cities in 2012

	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Participant characteristics				
Race/ethnicity				
White (reference)	1.00	1.00	1.00	1.00
Black	1.62 (1.39, 1.88)*	1.84 (1.58, 2.14)*	2.53 (1.27, 5.07)*	5.40 (3.08, 9.46)*
Latino	0.75 (0.65, 0.88)*	0.55 (0.47, 0.65)*	3.27 (1.82, 5.89)*	1.53 (0.97, 2.42)
Place characteristics				
Zip code (N = 889)				
Concentration of Black vs. White residents				
Interactions				
White PWID (reference)	0.55 (0.48, 0.62)*			
Black PWID/White PWID	3.17 (2.71, 3.71)*			
Latino PWID/White PWID	2.68 (2.24, 3.21)*			
Concentration of Latino vs. White residents				
Interactions				
White PWID (reference)		0.64 (0.58, 0.72)*		
Black PWID/White PWID		1.88 (1.61, 2.18)*		
Latino PWID/White PWID		2.74 (2.38, 3.15)*		
County (N = 53)				
Mortgage discrimination against Black residents				
Interactions				
White PWID (reference)			1.25 (1.03, 1.51) *	
Black PWID/White PWID			0.90 (0.78, 1.05)	
Latino PWID/White PWID			0.68 (0.60, 0.77)*	
Mortgage discrimination against Latino residents				
Interactions				
White PWID (reference)				1.17 (0.94, 1.45)
Black PWID/White PWID				0.71 (0.61, 0.82)*
Latino PWID/White PWID				0.77 (0.68, 0.87)*

⁶ Interaction models were separately run for each measure of racial/ethnic concentration and mortgage discrimination. White PWID serve as the reference group for all interactions. Standardized adjusted odds ratios are presented. Asterisk denotes $p < 0.05$

PWID/White PWID, AOR = 2.68, CI = 2.24, 3.21), suggesting the associations of ZIP code-level concentrations of Black vs. White residents with homophily among Black and Latino PWID varied from the inverse association among White PWID (AOR = 0.55, CI = 0.48, 0.62). Similarly, both interaction terms of PWID race/ethnicity with ZIP code-level concentrations of Latino vs. White residents were statistically significant (Black PWID/White PWID, AOR = 1.88, CI = 1.61, 2.18; Latino PWID/White PWID, AOR = 2.74, CI = 2.38, 3.15), suggesting the associations of ZIP code-level

concentrations of Latino vs. White residents with homophily among Black and Latino PWID varied from the inverse association among White PWID (AOR = 0.64, CI = 0.58, 0.72)

County-Level Mortgage Discrimination

The interaction term of Black race with county-level mortgage discrimination against Black residents was not statistically significant (AOR = 0.90, CI = 0.78, 1.05), suggesting the association of county-level mortgage discrimination against Black residents

Table 4 Multivariable models estimating associations of participant characteristics, ZIP code-level racial/ethnic concentration, and county-level mortgage discrimination with racial/ethnic homophily in sexual partnerships among people who inject drugs ($n = 7847$) living in 19 US cities in 2012

	Model A: full model, excluding interactions Adjusted odds ratio (95% CI)	Model B: full model, including interactions Adjusted odds ratio (95% CI)
Participant Characteristics		
Current age	1.04 (0.97, 1.11)	1.06 (0.99, 1.13)
Female	0.84 (0.74, 0.95)*	0.90 (0.79, 1.02)
Race/ethnicity		
White (reference)	1.00	1.00
Black	1.41 (1.19, 1.67)*	3.93 (1.82, 8.50)*
Latino	0.53 (0.45, 0.62)*	1.45 (0.75, 2.78)
Annual income	0.97 (0.91, 1.02)	0.95 (0.90, 1.01)
High school diploma/general equivalency diploma	0.86 (0.76, 0.97)*	0.91 (0.80, 1.03)
Full-time employment	0.78 (0.60, 1.02)	0.78 (0.59, 1.02)
Incarceration, past 12 months	0.94 (0.84, 1.06)	0.95 (0.85, 1.08)
Homelessness, past 12 months	0.79 (0.70, 0.89)*	0.83 (0.73, 0.94)*
Daily injection, past 12 months	1.10 (0.97, 1.25)	1.09 (0.95, 1.24)
Binge drinking, past 12 months	0.96 (0.85, 1.08)	0.97 (0.86, 1.09)
Non-injection drug use, past 12 months	0.95 (0.82, 1.09)	0.97 (0.84, 1.12)
Sex exchange, past 12 months	0.66 (0.59, 0.75)*	0.65 (0.58, 0.73)*
Region		
Northeast (reference)	1.00	1.00
South	1.67 (1.13, 2.46)*	1.47 (1.13, 1.90)*
Midwest	1.43 (0.81, 2.50)	1.11 (0.78, 1.60)
West	0.79 (0.52, 1.20)	0.88 (0.68, 1.15)
Place characteristics		
Zip code ($N = 889$)		
Concentration of Black vs. White residents	1.08 (0.97, 1.20)	
Interactions		
White PWID (reference)		0.63 (0.53, 0.75)*
Black PWID/White PWID		2.92 (2.36, 3.61)*
Latino PWID/White PWID		1.63 (1.29, 2.05)*
Concentration of Latino vs. White residents	1.00 (0.91, 1.10)	
Interactions		
White PWID (reference)		0.83 (0.72, 0.95)*
Black PWID/White PWID		1.06 (0.87, 1.30)
Latino PWID/White PWID		2.01 (1.67, 2.43)*
County ($N = 53$)		
Mortgage discrimination against Black residents	1.01 (0.82, 1.25)	
Interactions		
White PWID (reference)		1.31 (1.07, 1.60)*
Black PWID/White PWID		0.96 (0.74, 1.24)
Latino PWID/White PWID		0.62 (0.49, 0.79)*
Mortgage discrimination against Latino residents	0.99 (0.80, 1.23)	
Interactions		
White PWID (reference)		0.93 (0.78, 1.11)
Black PWID/White PWID		0.82 (0.65, 1.03)
Latino PWID/White PWID		1.36 (1.10, 1.69)*

Table 5 Race/ethnicity-specific associations⁷ of ZIP code-level racial/ethnic concentration and county-level mortgage discrimination with racial/ethnic homophily in sexual networks among people who inject drugs ($n = 7847$) living in 19 US cities in 2012

	Adjusted odds ratio (95% CI)
ZIP code-level concentrations of Black vs. White residents	
White	0.63 (0.53, 0.75)*
Black	1.84 (1.58, 2.15)*
Latino	1.03 (0.86, 1.23)
ZIP code-level concentrations of Latino vs. White residents	
White	0.83 (0.72, 0.95)*
Black	0.88 (0.75, 1.03)
Latino	1.66 (1.45, 1.91)*
County-level mortgage discrimination against Black residents	
White	1.31 (1.07, 1.60)*
Black	1.25 (1.00, 1.58)
Latino	0.82 (0.68, 0.99)*
County-level mortgage discrimination against Latino residents	
White	0.93 (0.78, 1.11)
Black	0.76 (0.62, 0.94)*
Latino	1.26 (1.06, 1.51)*

⁷ Post-estimation decomposition of interactions of PWID race/ethnicity with ZIP code racial/ethnic composition and county mortgage discrimination presented in Table 4—Model B

among Black PWID did not differ from the association among White PWID (AOR = 1.25, CI = 1.03, 1.51). In contrast, the interaction term of Latino ethnicity with county-level mortgage discrimination against Black residents was significant (AOR = 0.68, CI = 0.60, 0.77), suggesting that the association among Latino PWID differed from the association among White PWID. Both interaction terms of race/ethnicity with county-level mortgage discrimination against Latino residents were statistically significant (Black PWID/White PWID, AOR = 0.71, CI = 0.61, 0.82; Latino PWID/White PWID, AOR = 0.77, CI = 0.68, 0.87), suggesting the association of mortgage discrimination against Latino residents with homophily among Black and Latino PWID differed from the association among White PWID (AOR = 1.17, CI = 0.94, 1.45), which was not statistically significant.

Multivariable Models

In the first multivariable model (Table 4), no measure of ZIP code-level racial/ethnic concentration or county-level mortgage discrimination was significantly

associated with homophily (concentrations of Black vs. White residents, AOR = 1.08, CI = 0.97, 1.20; concentrations of Latino vs. White residents, AOR = 1.00, CI = 0.91, 1.10; mortgage discrimination against Black residents, AOR = 1.01, CI = 0.82, 1.25; mortgage discrimination against Latino residents, AOR = 0.99, CI = 0.80, 1.23). However, several interaction terms of race/ethnicity with ZIP code-level measures of racial/ethnic concentration and mortgage discrimination that were significant in “preliminary interaction models” remained statistically significant in the second multivariable model.

ZIP Code-Level Racial/Ethnic Concentration

With White PWID serving as the reference group, interaction terms of Black and Latino race/ethnicity with ZIP code-level concentrations of Black vs. White residents were significant in the second multivariable model (Black PWID/White PWID, AOR = 2.92, CI = 2.36, 3.61; Latino PWID/White PWID, AOR = 1.63, CI = 1.29, 2.05; Table 4). These results suggested associations among Black and Latino PWID differed from the inverse relationship of ZIP code-level concentrations of

Black vs. White residents to homophily observed among White PWID (AOR = 0.63, CI = 0.53, 0.75). Post-estimation of race/ethnicity-specific associations (see Table 5) revealed that higher ZIP code-level concentrations of Black vs. White residents were associated with higher odds of homophily among Black PWID (AOR = 1.84, CI = 1.58, 2.15) but were not significantly associated with homophily among Latino PWID (AOR = 1.03, CI = 0.86, 1.23).

The interaction term of Latino ethnicity with ZIP code-level concentrations of Latino vs. White residents was significant in the second multivariable model (AOR = 2.01, CI = 1.67, 2.43, Table 4), which suggested the association of ZIP code-level concentrations of Latino vs. White residents with homophily among Latino PWID varied from the inverse association among White PWID (AOR = 0.83, CI = 0.72, 0.95). The interaction term of Black race with ZIP code-level concentrations of Latino vs. Whites residents was not statistically significant (AOR = 1.06, CI = 0.87, 1.30), suggesting that the associations did not vary among Black and White PWID. Post-estimation of race/ethnicity-specific associations revealed that in contrast to the inverse significant association of ZIP code-level concentrations of Latino vs. White residents with homophily among White PWID, higher ZIP code-level concentrations of Latino residents vs. White residents were significantly associated with higher odds of homophily among Latino PWID (AOR = 1.66, CI = 1.45, 1.91, Table 5). The association of ZIP code-level concentrations of Latino residents vs. White residents with homophily was not statistically significant among Black PWID (AOR = 0.88, CI = 0.75, 1.03).

County-Level Mortgage Discrimination

The interaction of Latino ethnicity with county-level mortgage discrimination against Black residents was significant in the second multivariable model (AOR = 0.62, CI = 0.49, 0.79, Table 4), suggesting that the association of county-level mortgage discrimination against Black residents with homophily among Latino and White PWID differed. The interaction of Black race with county-level mortgage discrimination against Black residents was not significant (AOR = 0.96, CI = 0.74, 1.24), suggesting no difference in the association of county-level mortgage discrimination against Black residents with homophily among Black and White PWID. Post-estimation of race/ethnicity-specific

associations revealed that similar to White PWID (AOR = 1.31, CI = 1.07, 1.60), county-level mortgage discrimination against Black residents was associated with higher odds of homophily among Black PWID (AOR = 1.25, CI = 1.00, 1.58, Table 5), but the association was borderline significant. In contrast, mortgage discrimination against Black residents was significantly associated with lower odds of homophily among Latino PWID (AOR = 0.82, CI = 0.68, 0.99).

The interaction of Latino ethnicity with county-level mortgage discrimination against Latino residents was significant in the second multivariable model (1.36, CI = 1.10, 1.69, Table 4), which suggested the association between county-level mortgage discrimination against Latino residents and homophily among Latino PWID varied from the association among White PWID. There was no significant interaction of Black race with county-level mortgage discrimination against Latino residents (AOR = 0.82, CI = 0.65, 1.03), and this suggested that the association between county-level mortgage discrimination against Latino residents among Black PWID did not significantly vary from that among White PWID. Post-estimation of race/ethnicity-specific associations, however, revealed that in contrast to White PWID, among whom the association between county-level discrimination against Latino residents and homophily was not significant (AOR = 0.93, CI = 0.78, 1.11, Table 5), the association was significant and inverse among Black PWID (AOR = 0.76, CI = 0.62, 0.94) and significant and associated with higher odds of homophily among Latino PWID (AOR = 1.26, CI = 1.06, 1.51).

In the final multivariable model, with interactions added, PWID recruited from the South (vs. Northeast) were significantly more likely to report homophily in sexual partnerships (AOR = 1.47; CI = 1.13, 1.90). As compared to White PWID, Black PWID were also significantly more likely to report homophily in sexual partnerships (AOR = 3.93, CI = 1.82, 8.50). Homelessness (AOR = 0.83, CI = 0.73, 0.94) and sex exchange (AOR = 0.65, CI = 0.58, 0.73) in the past 12 months were significantly associated with lower odds of homophily (Table 4).

Post hoc Analysis

Because we were not powered to estimate multilevel relationships of ZIP code-level racial/ethnic concentration and county-level mortgage discrimination to *different types* of heterophily (e.g., sexual partnerships with

men and women who were not of the same racial/ethnic background) among PWID, we explored this possibility in post hoc descriptive analyses comparing distributions of heterophily below and above the median index of concentration of Black (or Latino) vs. White residents and mortgage discrimination. White PWID had higher (>10% difference) percentages of sexual partnerships with both Black and Latino partners when they resided in ZIP codes with higher concentrations of Black or Latino vs. White residents. When Black PWID resided in counties where Latino residents faced greater mortgage discrimination, they reported higher percentages of sexual partnerships with both White and Latino partners. Likewise, among Latino PWID, when they resided in counties where Black residents were discriminated against in the housing market, they reported higher percentages of sexual partnerships with both White and Black partners.

Discussion

On average, discriminatory mortgage lending practices and a high degree of racial/ethnic concentration were occurring in local areas where this sample of PWID lived. This study also revealed that racial/ethnic homophily in sexual partnerships is as common among PWID as it is among broader populations [6, 13, 54]. Racial/ethnic homophily in sexual partnerships were more frequent among Black PWID as compared to White and Latino PWID and PWID in the South as compared to PWID in the Northeast. This study also revealed several associations of racial/ethnic concentration and mortgage discrimination with racial/ethnic homophily in sexual partnerships among PWID, independent of individual-level factors. Specifically, Black and Latino PWID living in ZIP codes with higher concentrations of their racial/ethnic group (vs. White residents) had higher odds of racial/ethnic homophily in sexual partnerships. Additionally, among these PWID of color, odds of racial/ethnic homophily in sexual partnerships were higher among those who lived in counties where their racial/ethnic group faced mortgage discrimination. Odds of racial/ethnic homophily in sexual partnerships were lower among Black and Latino PWID when the other non-White group experienced mortgage discrimination at the county level. White PWID reported lower odds of homophily when they lived in ZIP codes where Black or Latino residents were more

concentrated than White residents and reported higher odds of homophily when they lived in counties where Black residents faced greater mortgage discrimination.

The higher odds of racial/ethnic homophily among Black and Latino PWID in ZIP codes where their racial/ethnic group outnumbered White residents and in counties where their racial/ethnic group faced mortgage discrimination may reflect *lack* of opportunities to interact and develop relationships with people of other racial/ethnic backgrounds at both levels of geography. These same processes may operate among White PWID living in counties where Black residents faced greater mortgage discrimination.

The higher odds of interracial or interethnic sexual partnerships among White PWID when they were outnumbered by non-White groups at the ZIP code-level counter the minority threat hypothesis, which posits that growth of an “other” racial/ethnic group encourages fear of and limited interaction with that group. Our findings suggest opposing dynamics, which align with prior research documenting associations of exposure to racially/ethnically diverse schools and neighborhoods with interracial friendships among young people [55, 56]. Such findings are supported by the “contact hypothesis” that suggests negative perceptions of a given racial/ethnic group that might arise when contact with that group is limited is minimized when contact with the group increases [57]. In addition, White PWID, in particular, may develop complex social identities that do not center on their “Whiteness” but their status as a marginalized person in society in some cities [58, 59]. Due to paucity of relevant literature, it remains unclear as to why Black and Latino PWID were more likely to partner with people outside their race/ethnicity when they resided in counties where the “other” non-White group faced greater mortgage discrimination.

Additional noteworthy findings include the fact that PWID in the South reported higher odds of racial/ethnic homophily in sexual partnerships than their Northern counterparts. This finding may reflect differing norms and acceptance of interracial partnerships in the South as compared to other regions [60] and structural factors not analyzed in this study.

The implications of this study’s findings for HIV transmission within racial/ethnic groups are complex. A growing line of literature supporting the ethnic density hypothesis suggests drug use and sexual behaviors

protective against HIV transmission manifest across predominantly Black social networks and within predominantly Black communities. Although these studies do not focus on transmission itself, research by Momplaisir and colleagues, for example, document associations of racially segregated networks among Black PWID with less syringe sharing among this group [9]. Relatedly, Bluthenthal and colleagues document lower condomless sex and distributive syringe sharing among PWID living in predominantly Black communities [61, 62].

However, even in the rare instances when Black and Latino PWID do engage in risky behaviors, the high background HIV/STI prevalence among Black and Latino PWID may still put them at higher risk of acquiring HIV/STI than their White counterparts. Indeed, among this sample of PWID who consented to receive HIV testing as part of NHBS, the proportion of Black PWID who tested positive for HIV was nearly double the proportion among White and Latino PWID. Prior mathematical models suggest segregated networks exacerbate isolated HIV epidemics within different racial/ethnic groups and potentially widen disparities in HIV transmission. Aligned with this theory, research conducted using data from men and women participating in NHBS in New York documented associations of higher bridging (e.g., high HIV transmission potential) in communities with higher percentages of Black or Latino residents [54].

The well-documented relationship of discriminatory housing practices and residential segregation with economic disinvestment and other community-level health hazards may play a significant role in facilitating HIV transmission within segregated networks of Black and Latino PWID. Because racial/ethnic segregation disproportionately sorts racial/ethnic minorities into impoverished and underserved neighborhoods, they are disproportionately exposed to features that are associated with HIV. Additionally, particularly among low-income residents, discriminatory housing practices and resultant spatial segregation may restrict their social networks to small spatial scales, [26] which may thereby hinder their efforts to establish relationships with residents of other communities who may be less exposed to community-level health hazards associated with HIV infection. These possibilities are supported by prior research, including our own, suggesting that HIV infection is homogenous across ZIP codes where Black and

Latino PWID reside [63], and research suggesting predominantly low income and racial/ethnic minority residents report sexual partnerships with residents of the same neighborhood or adjacent neighborhoods [17, 19, 41, 54, 64, 65].

There are several limitations that may influence interpretation of study findings. We were restricted to NHBS data collected in 2012; thus more recent housing-related and social partnering dynamics may not have been reflected in our data. Findings may not be generalizable to PWID residing in predominantly nonurban settings or cities with low HIV prevalence rates. The complex multilevel design precluded adjustment for respondent-driven sampling chains. Outcomes were based on perceived characteristics of the last sexual partner, but the median number of reported sexual partners was 2. Research using more recent surveys of PWID participating in NHBS document that among last, second-to-last, and third-to-last sexual partners, similarities between race/ethnicity across these partnerships are moderate [66]. Therefore, consideration of multiple partnerships in this sample may have resulted in a lower prevalence of homophily than that observed by taking a “single snapshot” of partnerships among PWID in this sample. However, regardless of the number of partners considered, concentrations of Black and Latino residents compared to white residents and housing discrimination against Black and Latino residents may associate with homophily in similar ways. Future research is needed to confirm this, however.

Lack of statistical power and relevant survey questions precluded us from analyzing subpopulations (e.g., by nativity, racial identity) of Latino participants and partners. Our interpretation of results assumes PWID develop partnerships with those living in the same ZIP code or county, and we were unable to confirm this. Prior research among predominantly low-income samples of adults, including those recruited to NHBS, however, suggest that partner selection often occurs within small geographic areas [17, 19, 41, 54, 64, 65].

Multilevel analyses have been documented to be biased when within-cluster associations differ from between-cluster associations [67]. To investigate this possibility, we used two different generalized estimating equations (GEE) with robust variance estimators to assess all associations estimated in multilevel models, as done elsewhere [67]. One GEE model had an independent correlation structure, and the other had an exchangeable correlation structure. Parameter estimates

and significance in both GEE models were similar suggesting that within-cluster and between-cluster associations did not vary.

Selection bias may also explain higher odds of racial/ethnic homophily of sexual partnerships among Black and Latino PWID living in ZIP codes where their group outnumbered white residents. Although we adjusted for several individual-level factors, we could not account for participants' preferences for residing in racially/ethnically segregated communities where the benefits of social capital, sense of belonging, cultural familiarity, and access to culturally tailored services and establishments are prevalent therein [29, 68]. We could not evaluate how well our mortgage discrimination measure captures the magnitude of complaints filed with federal and local agencies for violations to the Fair Housing Act. Relatedly, there may be correlates of mortgage loan denial, including credit scores that we did not measure. Due to low HIV incidence among this sample of PWID, we were not powered to explore how study findings may influence HIV transmission. Lastly, we were unable to investigate how personal partner preferences may confound or mediate the associations observed in this study.

Conclusion

This study is novel in documenting associations of mortgage discrimination and racial/ethnic concentration with racial/ethnic homophily in sexual partnerships among different racial/ethnic groups of PWID. Future studies should take this analysis further by quantifying the extent to which racial/ethnic homophily in sexual partnerships mediates relationships of racial/ethnic residential segregation to racial/ethnic disparities in HIV/STI transmission and determines the influence of community-level correlates of residential segregation along these pathways. Given the prominent role of networks in the social epidemiology of health outcomes among people who use drugs, this topic of study should be expanded to research on overdose prevention and response and other health outcomes among people who use drugs. Additional research in this area will deepen knowledge about the social epidemiology of HIV/STIs and other health outcomes and inform development of network-based interventions that are tailored to racial/ethnic groups of people who use drugs according to the level of racial/ethnic residential segregation where they live. With recent administrative cutbacks in funding for policies that guard against

institutional racism [69, 70], future research in this area may strengthen support for strategies that eliminate discriminatory housing policies.

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