HHS Public Access

Author manuscript

*Sex Transm Dis*. Author manuscript; available in PMC 2017 November 28.

Published in final edited form as:

*Sex Transm Dis*. 2016 April ; 43(4): 222–230. doi:10.1097/OLQ.0000000000000419.

# Public Housing Relocations and Partnership Dynamics in Areas With High Prevalences of Sexually Transmitted Infections

**Hannah L.F. Cooper, ScD**[*], **Loida Bonney, MD, MPH**[†], **Ruiyan Luo, PhD**[‡], **Danielle F. Haley**[*], **Sabriya Linton, PhD**[*], **Josalin Hunter-Jones, MSW, MPH**[*], **Zev Ross, MS**[§], **Gina M. Wingood, ScD**[*,¶], **Adaora A. Adimora, MD, MPH**[‖], and **Richard Rothenberg, MD, MPH**[‡]

[*]Department of Behavioral Sciences and Health Education, Rollins School of Public Health at Emory University, Atlanta, GA

[†]Division of General Medicine, Emory University School of Medicine, Atlanta, GA

[‡]Institute of Public Health at Georgia State University, Atlanta, GA

[§]ZevRoss Spatial Analysis, Ithaca, New York

[¶]Department of Sociomedical Sciences, Columbia University School of Public Health, New York, NY

[‖]University of North Carolina Schools of Medicine and Gillings School of Global Public Health, Chapel Hill, NC

## Abstract

**Background—**We investigated the implications of one structural intervention—public housing relocations—for partnership dynamics among individuals living areas with high sexually transmitted infection (STI) prevalence. High-prevalence areas fuel STI endemicity and are perpetuated by spatially assortative partnerships.

**Methods—**We analyzed 7 waves of data from a cohort of black adults (n = 172) relocating from 7 public housing complexes in Atlanta, Georgia. At each wave, data on whether participants' sexual partners lived in the neighborhood were gathered via survey. Participant addresses were geocoded to census tracts, and measures of tract-level STI prevalence, socioeconomic conditions, and other attributes were created for each wave. "High-prevalence tracts" were tracts in the highest quartile of STI prevalence in Georgia. Descriptive statistics and hierarchical generalized linear models examined trajectories of spatially assortative partnerships and identified predictors of assortativity among participants in high-prevalence tracts.

**Results—**All 7 tracts containing public housing complexes at baseline were high-prevalence tracts; most participants relocated to high-prevalence tracts. Spatially assortative partnerships had a U-shaped distribution: the mean percent of partners living in participants' neighborhoods at baseline was 54%; this mean declined to 28% at wave 2 and was 45% at wave 7. Participants who experienced greater postrelocation improvements in tract-level socioeconomic conditions had a

Correspondence: Hannah L.F Cooper, ScD, Department of Behavioral Sciences and Health Education, Rollins School of Public Health at Emory University, 1518 Clifton Rd NE, Atlanta, GA 30322. hcoope3@emory.edu.

Conflict of interest: None declared.

lower odds of having spatially assortative partnerships (adjusted odds ratio, 1.55; 95% confidence interval [95% CI], 1.06–2.26).

**Conclusions—**Public housing relocation initiatives may disrupt high-prevalence areas if residents experience significant postrelocation gains in tract-level socioeconomic conditions.

Public housing policies have reshaped urban environments in the United States since the 1950s. In the 1950s to 1970s, the Department of Housing and Urban Development (HUD) built large high-rises and campuses ("complexes") to contain 10,000 units of publicly subsidized housing.[1] By spatially concentrating impoverished residents, most of whom were black, these complexes created some of the highest poverty areas in the United States and deepened racial/ethnic residential segregation.[27] Since the 1990s, HUD has sought to reverse these policies by relocating residents of these complexes to voucher-subsidized rental units in the private market that are scattered across neighborhoods within a city and beyond; vacant complexes are subsequently demolished.[8] These relocations have prompted mass internal migrations: since the 1990s, 10,000 people have relocated from complexes slated for demolition.[8] Relocations tend to move people to neighborhoods that are less impoverished and violent than the neighborhoods containing the complexes.[9]

This article explores the possible implications of these relocations for core areas. "Core areas" are places with high prevalences of sexually transmitted infections (STIs) and of behaviors that fuel STI endemicity[10]; typically, they are conceptualized as places where the reproductive rate for an STI exceeds one.[11] A key feature of a core area is that its residents tend to have sexual partners who live closer to them than the partners of residents of noncore areas.[10,1214] These "spatially assortative" partnerships perpetuate core areas: because the core area has a high STI prevalence, partners chosen from this core are more likely to have an STI.[13,15,16] Past research on public housing relocations suggests that relocations move people from neighborhoods with high STI prevalences to neighborhoods with lower STI prevalences.[17] It also suggests that relocaters' sexual networks become less risky after relocation, and that individual- and neighborhood-level characteristics influence these changes.[18] Moreover, Youm et al.[19] have posited that public housing relocations in Chicago may have created sexual-network bridges between communities relocaters moved from and to.

Here, we analyze data from a cohort of black adults relocating from public housing complexes to (1) explore whether neighborhoods containing public housing complexes could be considered core areas (defined below), and whether relocations tended to take study participants to noncore areas; (2) describe temporal trajectories in spatially assortative partnerships among relocaters living in core areas; and (3) examine individual- and place-based predictors of assortativity in core areas. We explore these topics in a predominately substance-misusing cohort of relocaters. The prevalence of substance misuse is higher among public housing residents than it is in the general population.[2] Substance misusers help perpetuate cores, perhaps because they are more likely to have spatially assortative partnerships[13] and engage in high-risk sex.[21] Drawing on past research,[9,22–2] individual-and tract-level predictors of assortativity were selected to capture (1) opportunities to interact with neighbors, (2) opportunities to interact with people living *outside* one's neighborhood,

and (3) participant homophily with neighbors. Identifying true cores requires network-level data on STI status. In the absence of those data, we instead used administrative data to identify census tracts with high STI prevalence (“high-prevalence” tracts).

## MATERIALS AND METHODS

Methods have been described elsewhere[25] and are summarized here. This longitudinal multilevel study followed a cohort of people relocating from 7 public housing complexes in Atlanta, Georgia, that were targeted for demolition in 2008 to 2010; all residents of these complexes were relocated to voucher-subsidized rental units in the private market and the complexes were subsequently demolished. Baseline data were gathered in 2009 and captured the prerelocation period; waves 2 to 7 captured the postrelocation period and were gathered at approximately 9-month intervals. Wave 7 was completed in 2014.

### Sample, Recruitment, and Retention

People were eligible if they had lived for more than 1 year in 1 of the 7 public housing complexes, self-identified as a non-Hispanic black/African American adult (>18 years), had been sexually active in the past year, and did not live with a current study participant. We used non-probability-based quota sampling to create a sample that varied with regard to baseline substance misuse: ¼ of participants met the criteria for drug/alcohol dependence, ½ misused substances but were not dependent (i.e., self-reported recent use of illicit drugs or alcohol misuse, including binge drinking), and ¼ did not misuse substances (i.e., no illicit drug use in the past 5 years and no recent alcohol misuse). For this analysis, we restricted the analytic sample at each wave to people who had had sex in the past 6 months and who currently lived in a “high-STI-prevalence” census tract (defined later).

Study staff recruited onsite in each complex, varying days and times to reach residents with different activity patterns. Community- and faith-based organizations near each complex shared flyers with clients and parishioners. We implemented intensive retention methods (e.g., monthly calls to participants and contact with hard-to-reach participants’ network members) to keep attrition low and random.

### Data Collection and Measures

Individual-level data were gathered via survey at each wave. Participant home addresses were geocoded to census tracts at each wave, and administrative data analyzed to describe these tracts. Baseline data captured prerelocation census tract conditions; tract-level data for waves 2–7 were contemporaneous, with the year of survey-based data collection or with the most proximate year data available. Participants received $20 for the baseline interview; incentives increased by $5 at each subsequent wave.

### Defining High-Prevalence Areas

Using data from the Georgia Department of Health, we calculated STI prevalence as the sum of newly reported cases of gonorrhea, chlamydia, and syphilis per 1000 adults. We examined the annual distributions of newly reported STI cases across all Georgia tracts during the study period (n =1917–1986 tracts, depending on the year); tracts in the fourth quartile (>10

newly reported STI cases per 1000 adults) were classified as high-prevalence areas. We used tract-level data from Georgia instead of Atlanta to identify high-prevalence tracts because approximately 20% of the sample lived outside Atlanta at each wave after relocation.

### Outcome: Spatially Assortative Sexual Partnerships

At each wave, participants named up to 15 social network members with whom they had had sex, used alcohol (to excess) or illegal drugs, or "talked…relied on…[or] hung out," or who were family members whose "advice [they] were likely to seek and with whom [they] interacted" (past 6 months). They reported whether they had had sex with each network member (past 6 months) and whether each member currently lived in the participant's subjectively defined neighborhood. These questions generated variables capturing (1) the total number of sex partners (past 6 months) and (2) the number of partners (past 6 months) who lived in the participant's neighborhood.

### Individual-Level Predictors

Individual-level variables captured opportunities to interact with residents of participants' own tracts (e.g., neighboring) and with residents of *other* tracts (e.g., employment status), and participant homophily with residents of their own tracts (e.g., perceived economic status relative to neighbors'; Table 1). The Texas Christian University Drug Screen-II was used to assess substance dependence; people with scores at least 3 were classified as dependent during the eligibility screening. Additional measures captured participant sociodemographic characteristics (e.g., age and sex).

### Census-Tract Predictors

Tract-level variables captured opportunities to interact with residents of participants' own tract (e.g., sex ratios) and with residents of other tracts (unemployment rate), and participant homophily with residents of their own tracts (i.e., percent of residents who were black; Table 1). For each participant at each wave, data from the US Census Bureau and the Longitudinal Tract Database were used to calculate tract-level median income, poverty rates, high school dropout rates, sex ratios for black adults, the percentage of residents who had moved into the tract in the past year, and the percentage of residents who were black. We analyzed annual data from local police departments and the Georgia Department of Revenue to create tract-level measures of violent crime rates and alcohol outlet density (the number of businesses per square mile licensed to sell alcohol for off-premises consumption), respectively.

### Analysis

**Determine whether participants lived in high-prevalence tracts prerelocation and postrelocation—**We examined tract-level STI prevalence to determine whether participants lived in high-prevalence tracts at each of waves 1 to 7.

**Describe temporal trajectories in spatial assortativity in high-prevalence tracts—**After limiting each wave's sample to observations of sexually active participants in high-prevalence tracts, we examined plots of partner assortativity across waves, both overall and by substance dependence, to identify temporal trajectories. We then built a hierarchical

generalized linear model (HGLM) to model temporal trends ("growth curve model" [GCM]). Each HGLM discussed here had time (level 1) nested in participants (level 2), and participants nested in baseline tracts (level 3), and included a subject-specific intercept and slope for the number of months to/since relocation (wave 2). The number of sex partners who lived in the same neighborhood was assumed to have a binomial distribution with a sample size equal to the participant's total number of sexual partners; the probability that a sexual partner lived in the same neighborhood was related to predictors via a logit-link function. Models thus predicted the odds that a participant's partner lived in the participant's neighborhood, and these odds were the same for all partners of the same participant at that wave.

**Identify predictors of spatial assortativity in high-prevalence tracts—**HGLMs were used to assess bivariate[1] and multivariable relationships between tract- and individual-level characteristics and the odds that a participant's partner lived in the neighborhood. Because some tract-level predictors were correlated, we conducted a principal components analysis to avoid multicollinearity in the multivariable model. The principal components analysis identified a tract-level "socioeconomic disadvantage" component (median household income, percent black, and rates of unemployment, poverty, high school dropout, and violent crime; tracts with higher percentages of black residents were more disadvantaged because of persistent structural discrimination in the United States.[34]) Tract-level characteristics were centered at baseline,[35] creating a baseline measure and a "change since baseline" measure for each. Because participants dispersed postrelocation, tract-level "change since baseline" variables were treated as time-varying characteristics of individuals (level 1); baseline tract-level measures were characteristics of the 7 tracts containing the complexes (level 3). Because covariates were selected a priori for theoretical relevance, all were included in final multivariable models regardless of bivariate results. We examined whether substance misuse and sex moderated relationships of tract-level exposures to the outcome.

### Ethics

Emory University's institutional review board approved the study. A Certificate of Confidentiality was obtained to protect participants.

## RESULTS

Retention rates were high: 87% of the 172 baseline participants participated in wave 7 data collection. Of the 154 participants who were sexually active at baseline, 56.49% were women and the mean (SD) age was 42.48 (13.99) years (Table 2). Participants were impoverished at baseline: just 11.69% were employed full or part time, and 81.46% reported an annual household income lower than $12,500. Economic indicators improved somewhat postrelocation. By design, 18.83% of the sample was substance dependent at baseline; as reported elsewhere,[36] dependence declined over time.

[1]"Bivariate" models included one individual- or tract-level predictor and our measures of time.

Between waves 1 and 2, participants moved to new homes that were a mean (SD) of 5.81 (4.11) miles from the complexes where they lived at baseline. Many participants moved again: 60% of the wave 7 sample had moved at least once since the initial relocation. These moves took participants to census tracts that differed qualitatively from their baseline tracts. For example, the mean (SD) percentage of households in poverty in tracts where participants lived at baseline was 46% (10%); the mean (SD) for wave 2 was 32% (12%), 14 percentage points lower than that of their baseline tract, though still high. Tract-level poverty rates remained stable thereafter. Changes in almost all other tract-level conditions followed a similar pattern: high disadvantage at baseline, followed by substantial, sustained improvements.

### Determine whether participants live in high-prevalence tracts

All 7 baseline tracts (i.e., tracts containing housing complexes) met the criterion for a high-prevalence tract (>10 cases/1000 adults). In 3 of the 7 baseline tracts, STI prevalences exceeded 53 cases/1000 adults; in another 3 tracts, the prevalence was 30–40/1000. The STI prevalence in the seventh tract was lower (13/1000) but still above the 10/1000 cutpoint. To contextualize these baseline tracts, we ranked all of the tracts in the city of Atlanta (n = 137) by STI prevalence and found that 3 of the baseline tracts were in the top 15 for the city and 5 were in the top 30.

Although relocations scattered participants to tracts with lower STI prevalences (wave 1 tract-level STI-prevalence mean [SD], 47.50 [17.03]; wave 2 tract-level STI-prevalence mean [SD], 32.36 [12.20]), almost all participants lived in a high-prevalence tract postrelocation. Of the 122 participants in the whole sample living in Atlanta at wave 2, for example, just 13 lived in 1 of the 49 tracts that had an STI prevalence below 10/ 1000, whereas 46 lived in a tract that was in the top 30 for STI prevalence in the city. Notably, STI prevalence in the tracts that had once contained housing complexes dropped dramatically after the complexes were emptied: between waves 1 and 2, STI prevalence in 5 of these 7 tracts dropped 39% to 68% (69/1000 to 47/ 1000, 67/1000 to 26/1000, 40/1000 to 17/1000, 39/1000 to 16/ 1000, 14/1000 to 9/1000).

### Describe temporal trajectories in spatial assortativity in high-prevalence tracts

Spatial assortativity among participants in high-prevalence tracts had a U-shaped temporal trajectory. The mean (SD) percentage of participants' sex partners who lived in the neighborhood dropped from 54% (47%) at baseline to 28% (45% and 44%, respectively) at waves 2 to 3, and then rose gradually to 45% (49%) at wave 7 (Fig. 1 and Table 2). Trajectories varied somewhat by substance dependence status: substance-dependent participants reported more partners in the neighborhood at baseline (means of 78% vs. 48%) and the rate of decline in this outcome was steeper.

Table 3 depicts the optimal GCM for the odds that a participant's partner lives in the neighborhood. Together, the $\beta = -0.07$ for the variable "number of months to/since relocation" and the $\beta = 0.003$ for the square of this variable create a U-shaped trajectory; the $\beta = -0.15$ for the variable capturing whether 30 months elapsed allows the trajectory to descend at wave 7. A $\beta = 1.21$ for the substance-dependence variable indicates that drug

users had a higher odds of having a neighborhood partner at wave 2; the interaction of substance dependence with "number of months to/since relocation" ($\beta = -0.04$) indicates that substance misusers experienced greater postrelocation declines in the odds of having a neighborhood partner.

### Identify predictors of spatial assortativity in high-prevalence tracts

The multivariable model suggests that postrelocation changes in tract-level socioeconomic conditions were associated with the odds that a participant's partner lived in the neighborhood (adjusted odds ratio [AOR], 1.55; 95% CI, 1.07–2.26; Table 4). A 1-SD increase in the tract-level socioeconomic disadvantage component was associated with a 55% increase in the odds that a participant's partner lived in the same neighborhood; an alternative interpretation (reached by calculating the inverse of 1.55) is that a 1-SD *improvement* in tract-level socioeconomic conditions was associated with a 36% decline in the odds that a participant's partner lived in the same neighborhood. In these tracts, the mean violent crime rate was 15.3 incidents/1000 below the sample mean, household income was $27,736 above this mean, and the percentages of adults who were high school dropouts, adults who were unemployed, households that were in poverty, and residents who were black were 5%, 9%, 16%, and 42% points below the sample mean, respectively.

To explore whether specific variables in the socioeconomic component might be responsible for the association, we ran several variants of the final model, one for each of the component's constituent variables. The following tract-level variables were associated with the outcome: postrelocation changes in unemployment rates (AOR, 1.049; 95% CI, 1.001–1.100), high school dropout rates (AOR, 1.042; 95% CI, 1.004–1.082), and the percent of residents who were black (AOR, 1.021; 95% CI, 1.002–1.040; data available upon request).

The relationship between individual substance dependence and the odds that a participant's partner lived in the same neighborhood was described earlier; no other individual-level variables were associated with spatial assortativity. Neither substance misuse nor sex moderated relationships between tract-level exposures and the outcome.

## DISCUSSION

These results are aligned with a social epidemiologic approach that posits that structural determinants shape sexual networks.[17–19,37,38] The tracts containing the 7 public housing complexes where participants lived at baseline had extremely high STI prevalences; although STI prevalences were lower in post-relocation tracts, most participants nonetheless lived in high-prevalence postrelocation tracts. On average, participants reported that approximately half of their partners lived in the neighborhood at baseline (substance-dependent participants had higher means); this proportion declined in the initial months after relocation and then began to climb. The odds that a partnership was spatially assortative depended on tract-level conditions: participants who experienced greater postrelocation improvements in tract-level socioeconomic conditions were less likely to have local sex partners.

The U-shaped temporal trajectory of spatial assortativity likely reflects the process of postrelocation social integration: relocations moved participants away from partners living in the public housing neighborhoods, and participants gradually formed new ties (sexual and otherwise) with residents of their new neighborhoods. One underlying premise of relocation policies is that residents relocating to less disadvantaged neighborhoods will form new social ties through which they can access social capital and jobs.[39] Social integration is, however, a double-edged sword in this context: although social integration with neighbors confers a variety of benefits, particularly for impoverished people,[39] sexual relationships to neighbors in a high-prevalence tract may perpetuate cores and increase the likelihood that individual participants would become infected with an STI.

Even within this group of high-prevalence tracts, there was heterogeneity in tract-level socioeconomic conditions, and we found that greater postrelocation reductions in tract-level unemployment rates, high school dropout rates, and the percent of residents who were black were associated with lower odds of spatially assortative partnerships. To support future social epidemiologic research on structural interventions, neighborhoods, and networks, we generate hypotheses about mechanisms underlying these associations. Sociological research suggests that because they forge ties with coworkers, employed people develop larger social networks that extend beyond their own neighborhoods; likewise, greater educational attainment is associated with larger networks.[31] Because of these ties, more “outsiders” might flow through tracts with higher concentrations of employed people and high school graduates. As a result, residents of these tracts (including relocaters, who may or may not be employed/high school graduates themselves) might have more opportunity to meet and form relationships to people who lived outside the neighborhood. Sexual networks are highly assortative with respect to race/ethnicity,[23] and so participants (all of whom were black) who moved to tracts with lower percentages of black residents might have formed relationships to partners who lived elsewhere. Future research should test these hypotheses.

Our finding that the tracts containing housing complexes had high STI prevalences before the relocations, coupled with other studies’ findings of high-risk behavior and networks among residents of some complexes,[20,40] generates another hypothesis that merits inquiry: public housing policies that created these complexes may have incubated core areas. Public housing complexes constructed in 1950s–1970s created new pockets of concentrated poverty and exacerbated racial/ethnic residential segregation by moving predominately black, poor households that had previously been scattered across the city’s neighborhoods to complexes located in predominately black neighborhoods.[2–6,11,25,41] Core areas tend to be impoverished.[12] Impoverished, predominately black neighborhoods may be particularly vulnerable to becoming core areas because spatial isolation, partner preference, and discrimination by other groups fosters spatial assortativity and concentrated STIs.[23,24] Future research should explore whether public housing complexes incubated core areas in US cities.

An ideal measure of core areas would analyze geo-referenced network data on STIs. These data were not available to us. Bernstein et al.[42] identified core areas using the top quintile of reported gonorrhea cases in Baltimore, MD (resulting in a cutpoint of 10 case/1000, identical to our cutpoint), and found that these cores correlated well with cores based on

repeat-gonorrhea cases when larger distances were used, though not when smaller distances were used.

Because we sought to oversample active substance misusers, our sample is not generalizable to the underlying resident population in each complex. As discussed elsewhere,[25] however, our sample's sociodemographic composition was similar to those of the underlying populations of residents in each of the 7 complexes, as documented by HUD.

Baseline data were gathered after participants had learned that their complexes were scheduled for demolition. This knowledge may have altered baseline partnerships in unknown ways. In addition, as is common in egocentric studies, we do not know where participants' nonlocal partners lived, and thus do not know whether nonlocal partners lived in high-prevalence tracts.

## CONCLUSIONS

Future research should explore whether policies that spatially concentrate public housing residents incubate cores. Public housing relocation initiatives may have the potential to disrupt cores if they strive to ensure that residents experience significant postrelocation gains in tract-level socioeconomic conditions.

## Acknowledgments

This study was supported by the following: a CFAR03 grant awarded by the Emory Center for AIDS Research (P30 AI050409), "Public Housing Relocations: Impact on Healthcare Access, Drug Use & Sexual Health" (R21DA027072), "Public Housing Relocations: Impact on HIV and Drug Use" (R01DA029513), the GSU Center for Excellence in the Study of Health Disparities (P20MD004806), a National Research Service Award (F31MH105238), and a George W Woodruff Fellowship from Emory University's Laney Graduate School.

## References

1. Stoloff, J. A Brief History of Public Housing. Washington, DC: Office of Policy Development and Research, HUD; ND;
2. Carter WH, Schill MH, Wachter SM. Polarisation, public housing and racial minorities in US cities. Urban Stud. 1998; 35:1889–1911.
3. Hirsch, AR. Making the Second Ghetto: Race and Housing in Chicago 1940–1960. Chicago, IL: The University of Chicago Press; 1998.
4. Massey, D., Denton, N. American Apartheid: Segregation and the Making of the Underclass. Cambridge, MA: Harvard University Press; 1993.
5. Massey D, Kanaiaupuni S. Public housing and the concentration of poverty. Soc Sci Q. 1993; 74:109–122.
6. Schill MH. Distressed public housing: Where do we go from here? Univ Chicago Law Rev. 1993; 60:497–554.
7. Schill MH, Wachter SM. The spatial bias of federal housing law and policy: Concentrated poverty in urban America. Univ Pa Law Rev. 1995; 143:1285–1342.
8. Popkin, S., Katz, B., Cunningham, M., et al. A Decade of HOPE VI: Research Findings and Policy Challenges. The Urban Institute; Washington, DC: 2004.
9. Laumann, E., Ellingson, S., Mahay, J., et al. The Sexual Organization of the City. Chicago, IL: University of Chicago Press; 2004.
10. Gesink DC, Sullivan AB, Miller WC, et al. Sexually transmitted disease core theory: Roles of person, place, and time. Am J Epidemiol. 2011; 174:81–89. [PubMed: 21540320]

11. Thomas JC, Tucker MJ. The development and use of the concept of a sexually transmitted disease core. J Infect Dis. 1996; 174(suppl 2):S134–S143. [PubMed: 8843243]
12. Rothenberg RB. The geography of gonorrhea. Empirical demonstration of core group transmission. Am J Epidemiol. 1983; 117:688–694. [PubMed: 6859024]
13. Rothenberg R, Muth SQ, Malone S, et al. Social and geographic distance in HIV risk. Sex Transm Dis. 2005; 32:506–512. [PubMed: 16041254]
14. Zenilman JM, Ellish N, Fresia A, et al. The geography of sexual partnerships in Baltimore: Applications of core theory dynamics using a geographic information system. Sex Transm Dis. 1999; 26:75–81. [PubMed: 10029979]
15. Rothenberg R. Maintenance of Endemicity in urban environments: A hypothesis linking risk, network structure and geography. Sex Transm Infect. 2007; 83:10–15. [PubMed: 17283360]
16. Aral SO, Hughes JP, Stoner B, et al. Sexual mixing patterns in the spread of gonoccocal and chlamydial infections. Am J Public Health. 1999; 89:825–833. [PubMed: 10358670]
17. Cooper HLF, Haley DF, Linton S, et al. Impact of public housing relocations: Are changes in neighborhood conditions related to STIs among relocaters? Sex Transm Dis. 2014; 41:573–579. [PubMed: 25211249]
18. Cooper HL, Linton S, Haley DF, et al. Changes in exposure to neighborhood characteristics are associated with sexual network characteristics in a cohort of adults relocating from public housing. AIDS Behav. 2015; 16:1016–1030.
19. Youm Y, Mackesy-Amiti ME, Williams CT, et al. Identifying hidden sexual bridging communities in Chicago. J Urban Health. 2009; 86:107–120. [PubMed: 19543836]
20. Sikkema K, Koob J, Cargill V, et al. Levels and predictors of HIV risk behavior among women in low-income public housing developments. Public Health Rep. 1995; 110:707–713. [PubMed: 8570824]
21. Semaan S, Des Jarlais DC, Sogolow E, et al. A meta-analysis of the effect of HIV prevention interventions on the sex behaviors of drug users in the United States. J Acquir Immune Defic Syndr. 2002; 30:1. [PubMed: 12048357]
22. Watson D, Klohnen EC, Casillas A, et al. Match makers and deal breakers: Analyses of assortative mating in newlywed couples. J Pers. 2004; 72:1029–1068. [PubMed: 15335336]
23. Laumann EO, Youm Y. Racial/ethnic group differences in the prevalence of sexually transmitted diseases in the United States: A network explanation. Sex Transm Dis. 1999; 26:250–261. [PubMed: 10333277]
24. Gindi RM, Sifakis F, Sherman SG, et al. The geography of heterosexual partnerships in Baltimore city adults. Sex Transm Dis. 2011; 38:260–266. [PubMed: 20966827]
25. Cooper HL, Hunter-Jones J, Kelley ME, et al. The aftermath of public housing relocations: Relationships between changes in local socioeconomic conditions and depressive symptoms in a cohort of adult relocaters. J Urban Health. 2014; 91:223–241. [PubMed: 24311024]
26. Buckner J. The development of an instrument to measure neighborhood cohesion. Am J Community Psychol. 1988; 16:771–791.
27. Forrest R, Kearns A. Social cohesion, social capital and the neighbourhood. Urban Stud. 2001; 38:2125–2143.
28. Adimora A, Schoenbach VJ. Contextual Factors and the black-White Disparity in Heterosexual HIV Transmission. Epidemiology. 2002; 13:707–712. [PubMed: 12410013]
29. Bennett GG, McNeill LH, Wolin KY, et al. Safe to walk? Neighborhood safety and physical activity among public housing residents. PLoS Med. 2007; 4:1599–1606. [PubMed: 17958465]
30. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: A multilevel study of collective efficacy. Science. 1997; 277:918–924. [PubMed: 9252316]
31. McPherson M, Smith-Lovin L, Cook JM. Birds of a feather: Homophily in social networks. Annu Rev Sociol. 2001; 27:415–444.
32. Litman, T. [Accessed July 12, 2015] Measuring transportation: Traffic, mobility and accessibility. ITE J. 2003 Oct. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.376.711&rep=rep1&type=pdf

33. Adler NE, Singh-Manoux A, Schwartz JE, et al. Social status and health: A comparison of British civil servants in Whitehall II with European- and African-Americans in CARDIA. Soc Sci Med. 2008; 66:1034–1045. [PubMed: 18180089]

34. Oliver, ML., Shapiro, TM. Black Wealth/White Wealth: A New Perspective on Racial Inequality. 2. New York, NY: Routledge; 2006.

35. Singer, J., Willett, J. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. New York City: Oxford University Press; 2003.

36. Cooper HL, Bonney LE, Ross Z, et al. The aftermath of public housing relocation: Relationship to substance misuse. Drug Alcohol Depend. 2013; 133(1):37–44. [PubMed: 23850372]

37. Aral SO. Understanding racial-ethnic and societal differentials in STI. Sex Transm Infect. 2002; 78:2–4. [PubMed: 11872846]

38. Blanchard JF, Aral SO. Emergent properties and structural patterns in sexually transmitted infection and HIV research. Sex Transm Infect. 2010; 86(suppl 3):ii4–iii9.

39. Clampet-Lundquist S. HOPE VI relocation: Moving to new neighborhoods and building new ties. Housing Policy Debate. 2004; 15(2):415–447.

40. Tobin KE, Hester L, Davey-Rothwell MA, et al. An examination of spatial concentrations of sex exchange and sex exchange norms among drug users in Baltimore, Maryland. Ann Assoc Am Geogr. 2012; 102:1058–1066. [PubMed: 23626374]

41. Casey, C. Characteristics of HUD-Assisted Renters and Their Units in 1989. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research; 1992.

42. Bernstein KT, Curriero FC, Jennings JM, et al. Defining core gonorrhea transmission utilizing spatial data. Am J Epidemiol. 2004; 160:51–58. [PubMed: 15229117]

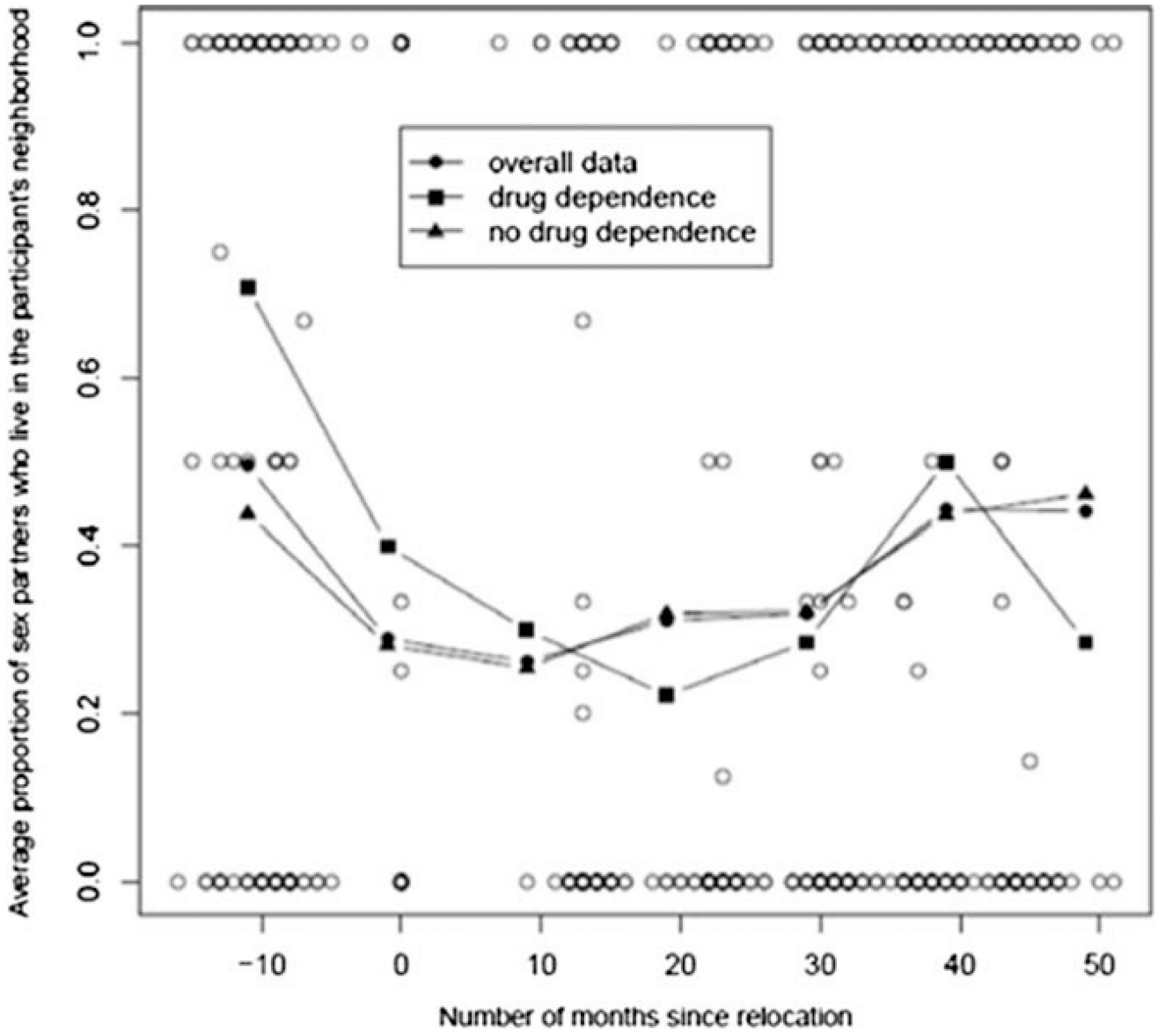


**FIGURE 1.**

Plot of the mean proportion of sex partners who lived in the participants' neighborhood restricted to sexually participants living in census tracts with high prevalences of STIs, overall and classified by substance-dependent status.

## TABLE 1

Individual-Level and Census-Tract Level Exposure Variables, Organized by Domain

| Domain | Individual-Level Measures | Tract-Level Measures | Citations Suggesting a Plausible Relationship to Spatial Assortativity |
|---|---|---|---|
| Extent to which opportunities exist to interact with other residents of one's own census tract | • Neighboring (range, 0–16; higher values indicate more frequent interactions with neighbors)<br>• Perceived community violence (range: 0–5; higher values indicate more frequent, severe violence in past 6 mo)<br>• Months participant has lived in the neighborhood | • Sex ratios for black adults<br>• Proportion of residents that had moved into the tract in the past year<br>• Violent crime rate<br>• Alcohol outlet density | Refs.[27–29] |
| Extent to which opportunities exist to interact with residents of *other* census tracts | • Current employment status<br>• Transportation barriers (range 0–8; higher values indicate more frequent inability to do something because of transportation problems in the past 6 months)[32]<br>• High school dropout<br>• Annual household income<br>• Distance between current home and home at last wave<br>• Current homeless status | • Median income<br>• Proportion of people aged 16 and over who are unemployed<br>• Proportion of households in poverty<br>• Proportion of adults who dropped out of high school | Ref.[31] |
| Participant homophily with residents of his/her census tract | • Perceived current economic status, relative to neighbors' (range, 1–9; a value of 1 indicates perceived parity with the poorest neighbors, a value of 9 indicates perceived parity with the wealthiest neighbors) | • Proportion of residents who are black | Refs.[9,23,31] |

*Sex Transm Dis*. Author manuscript; available in PMC 2017 November 28.

**TABLE 2**

Distributions of Individual- and Census-Tract Level Characteristics Over Time in a Sample of Black Adults Relocating From Public Housing Complexes in Atlanta, Georgia, Limited to Participants Who Were Sexually Active and Lived in Census Tracts With High Prevalences of STIs

| Characteristics of Participants and Census Tracts | Wave 1 (n = 154), % (n) or Mean (SD) | Wave 2 (n = 118), % (n) or Mean (SD) | Wave 3 (n = 115), % (n) or Mean (SD) | Wave 4 (n = 122), % (n) or Mean (SD) | Wave 5 (n = 109), % (n) or Mean (SD) | Wave 6 (n = 101), % (n) or Mean (SD) | Wave 7 (n = 111), % (n) or Mean (SD) |
|---|---|---|---|---|---|---|---|
| Participant characteristics | | | | | | | |
| No. sexual partners who live in neighborhood (past 6 mo) | 0.79 (0.84) | 0.30 (0.46) | 0.34 (0.54) | 0.35 (0.48) | 0.45 (0.50) | 0.49 (0.50) | 0.48 (0.50) |
| Total number of sex partners (past 6 mo) | 1.32(1.01) | 0.87 (0.84) | 1.17(1.04) | 0.98 (0.92) | 1.00(0.77) | 0.85 (0.72) | 0.94 (0.87) |
| Percent of sexual partners who lived in the neighborhood (past 6 mo) | 53.8 (47.5) | 28.0 (44.6) | 27.7 (43.8) | 32.8 (46.5) | 39.4 (46.9) | 44.1 (48.4) | 45.5 (49.0) |
| Sex * | | | | | | | |
| Man | 43.5 (67) | 38.1 (45) | 41.7(48) | 42.6 (52) | 43.1 (47) | 44.6 (45) | 42.3 (47) |
| Woman | 56.5 (87) | 61.9(73) | 58.3 (67) | 57.4 (70) | 56.9 (62) | 55.5 (56) | 57.7 (64) |
| Age, y | 42.48 (13.99) | 40.48 (13.63) | 40.12 (13.93) | 41.34(13.63) | 39.89 (13.95) | 40.68 (14.08) | 40.14(13.74) |
| Married or living as married | 10.4 (16) | 15.4 (14) | 11.3(13) | 9.0(11) | 13.8(15) | 10.9(11) | 9.0 (10) |
| Employed | 11.7(18) | 15.3 (18) | 20.9 (24) | 19.2 (23) | 20.4 (22) | 16.8(17) | 24.3 (27) |
| No high school diploma/GED | 61.7(95) | 56.4 (66) | 58.8 (67) | 59.5 (72) | 57.4 (62) | 56.0 (56) | 56.4 (62) |
| Annual household income | | | | | | | |
| ≤$12,500 | 81.46(123) | 79.28 (88) | 74.77 (83) | 83.76 (98) | 73.79 (76) | 71.88(69) | 61.11 (66) |
| ≥$12,500 | 18.54 (28) | 20.72 (23) | 25.23 (28) | 16.24 (19) | 26.21 (27) | 28.12(27) | 38.90 (27) |
| Homeless | 0% (0) | 5.1 (6) | 3.4(4) | 2.5 (3) | 2.8 (3) | 2.0 (2) | 5.4 (6) |
| Met screening criteria for dependence on alcohol or other drugs (6-mo reporting period) | 18.8 (29) | 5.9 (7) | 11.3(13) | 8.2 (10) | 8.3 (9) | 8.9 (9) | 8.1 (9) |
| Frequency of barriers to transportation | 3.08 (2.67) | 2.46 (2.62) | 1.55(1.99) | 1.71 (2.14) | 1.67(2.23) | 0.91(1.59) | 1.44(2.22) |
| No. months in the neighborhood | 111.18(115.13) | 15.67(50.66) | 68.70(136.16) | 51.13(103.96) | 49.34 (79.79) | 75.17(110.27) | 58.24 (79.48) |
| Distance moved since last wave (miles) | 0(0) | 5.81(4.11) | 1.51 (3.43) | 2.08 (4.48) | 1.19(3.47) | 1.26(4.32) | 1.74(4.42) |
| Perceived relative economic status | 4.55 (2.02) | 4.63(1.94) | 4.76(1.58) | 4.53(1.70) | 4.56(1.70) | 4.68(1.79) | 4.96(1.77) |
| Buckner neighboring index | 7.47 (3.89) | 6.64(3.56) | 6.57 (3.68) | 7.12 (2.80) | 6.51 (3.02) | 6.09 (3.62) | 5.75 (3.71) |
| Perceived community violence | 2.83 (2.22) | 0.74(1.24) | 0.82(1.37) | 0.60(1.03) | 0.89(1.38) | 1.03(1.55) | 0.89(1.57) |
| Census tract characteristics | | | | | | | |
| Prevalence of newly diagnosed gonorrhea, chlamydia, and syphilis, per 1000 adult residents | 47.5 (17.03) | 32.4 (12.20) | 34.9 (15.20) | 34.3 (14.70) | 35.0 (14.22) | 35.8 (14.94) | 34.8(14.25) |
| Sex ratio for black adults | | | | | | | |
| <95 men for every 100 women | 100.00 (154) | 65.25 (77) | 72.17(83) | 75.41 (92) | 70.64 (77) | 74.26 (75) | 74.77 (83) |
| 95–105 men for every 100 women | 0.00 (0) | 26.27(31) | 20.87 (24) | 16.39(20) | 23.85 (26) | 20.79 (21) | 18.29 (21) |

| Characteristics of Participants and Census Tracts | Wave 1 (n = 154), % (n) or Mean (SD) | Wave 2 (n = 118), % (n) or Mean (SD) | Wave 3 (n = 115), % (n) or Mean (SD) | Wave 4 (n = 122), % (n) or Mean (SD) | Wave 5 (n = 109), % (n) or Mean (SD) | Wave 6 (n = 101), % (n) or Mean (SD) | Wave 7 (n = 111), % (n) or Mean (SD) |
|---|---|---|---|---|---|---|---|
| >105 men for every 100 women | 0.00 (00 | 8.47 (10) | 6.96 (8) | 8.20(10) | 5.50 (6) | 4.95 (5) | 6.31 (7) |
| Percent of residents who have lived in the tract for <1 y | 29.7 (7.45) | 24.9 (8.75) | 24.2 (8.82) | 25.0 (9.41) | 25.8 (9.72) | 25.4 (10.43) | 25.4(11.09) |
| Density of alcohol outlets (per sq mi) | 9.12(7.96) | 6.17 (5.25) | 6.36(5.24) | 6.81 (6.17) | 6.93(6.15) | 6.44(5.11) | 6.30 (5.75) |
| Percent of residents who are black | 81.2(17.65) | 80.6 (23.68) | 77.9 (24.63) | 78.0 (24.70) | 80.1 (23.68) | 81.0(22.38) | 81.5(21.71) |
| Median household income | 15,917.46 (4568.36) | 30,233.06 (12,969.94) | 31,209.03 (14,260.37) | 31,090.96 (16,300.96) | 30,901.58(14,629.27) | 30,496.38 (14,372.88) | 31,636.25 (14,889.56) |
| Percent in poverty | 46.0 (9.72) | 31.6(11.54) | 31.6(12.04) | 32.7 (12.82) | 33.6 (12.24) | 34.6 (13.46) | 33.9(11.72) |
| Percent of adults (≥25 y) without a high school diploma | 39.0 (10.36) | 20.1 (7.53) | 20.3 (8.14) | 19.0 (7.45) | 19.7(7.16) | 19.3 (6.79) | 19.0(6.81) |
| Percent of residents aged | 21.0(5.36) | 18.9 (7.72) | 17.9 (7.39) | 19.0 (7.49) | 20.0 (7.33) | 21.0(7.77) | 21.4(7.43) |
| ≥ 16 y who are unemployed | | | | | | | |
| Violent crime rate (per 1000) | 35.29 (15.83) | 22.66 (13.90) | 22.95 (14.95) | 21.62(14.94) | 23.00 (14.68) | 23.23 (13.25) | 21.87(12.88) |
| Socioeconomic disadvantage component[†] | 0.95 (0.67) | -0.04 (0.79) | -0.09 (0.84) | -0.07 (0.88) | 0.02 (0.82) | 0.10(0.84) | 0.03 (0.80) |

[*] Women included 3 individuals who were transgendered (male to female).

[†] Consists of median household income, unemployment rate, poverty rate, high school dropout rate, violent crime rate, and percent of residents who are black.

## TABLE 3

GCM for the Odds That a Participant's Sex Partner Lived in the Participant's Neighborhood in a Sample of Black Adults Relocating From 7 Public Housing Complexes, Limited to Participants Who Lived in Census Tracts With High Prevalences of STIs

| Temporal Variables | $\beta$ (*P* value)* |
|---|---|
| Intercept | −1.39 (<0.0001) |
| 30 mo postrelocation or not | −0.15 (0.01) |
| No. months to/since relocation | −0.07 (<0.0001) |
| No. months to/since relocation, squared | 0.003 (<0.0001) |
| No. months to/since relocation × substance dependence | −0.04 (0.03) |
| Substance dependent | 1.21 (0.004) |

Relationships were modeled using HGLMs.

*We report $\beta$ values for the GCM because odds ratios are difficult to interpret in the presence of a nonlinear associations.

## TABLE 4

Bivariate and Multivariable Relationships Between Each Individual- and Census-Tract Level Predictor and the Odds That a Participant's Sex Partner Lived in the Participant's Neighborhood in a Sample of Black Adults Relocating From 7 Public Housing Complexes, Limited to Participants Who Lived in Census Tracts With High Prevalences of STIs

| Characteristics of Participants and Census Tracts | Bivariate Models,* Odds ratio (95% CI) | Multivariable Model, AOR (95% CI) |
|---|---|---|
| Intercept | See Table 3 | 1.586 (0.084–30.075) |
| 30 mo postrelocation or not | | 0.878 (0.757–1.019) |
| No. months to/since relocation | | |
| Substance dependent | | 0.914 (0.859–0.973) |
| Not substance dependent | | 0.957 (0.909–1.007) |
| No. months to/since relocation, squared | | 1.002 (1.001–1.004) |
| Substance dependent | | 1.757 (0.625–4.942) |
| Sex (reference, women) | 0.862 (0.383–1.941) | 1.076 (0.453–2.558) |
| Age (at baseline) | 0.997 (0.961–1.035) | 1.020 (0.986–1.055) |
| Married or living as married† | 7.491 (3.316–16.923) | — |
| Employed | 1.709 (0.839–3.481) | 1.361 (0.636–2.912) |
| No high school diploma/GED | 0.567 (0.257–1.251) | 0.633 (0.290–1.382) |
| Household income (in $10,000 units) | | |
| Baseline for substance-dependent participants | 1.493 (0.620–3.596) | 1.308 (0.519–3.298) |
| Baseline for nondependent participants | 1.499 (0.979–2.294) | 1.546 (0.950–2.516) |
| Change since baseline for substance-dependent participants | 3.640 (1.278–10.365) | 3.934 (1.172–13.201) |
| Change since baseline for non-substance-dependent participants | 1.080 (0.802–1.455) | 1.199 (0.867–1.658) |
| Homeless | 0.359 (0.141–0.915) | 0.585 (0.172–1.984) |
| Frequency of barriers to transportation | | |
| Baseline | 0.993 (0.810–1.217) | 1.083 (0.916–1.282) |
| Change since baseline | 0.875 (0.765–1.000) | 0.909 (0.792–1.044) |
| No. months in the neighborhood | | |
| Baseline | 1.000 (0.996–1.003) | 0.998 (0.995–1.002) |
| Change since baseline | 1.003 (1.001–1.006) | 1.002 (0.999–1.005) |
| Miles moved since last wave | | |
| Substance-dependent participants | 1.100 (0.945–1.280) | 1.007 (0.829–1.224) |
| Non-substance dependent participants | 0.942 (0.881–1.007) | 0.959 (0.884–1.039) |
| Perceived relative economic status | | |
| Baseline | 1.208 (0.854–1.236) | 0.971 (0.785–1.202) |
| Change since baseline | 1.111 (0.964–1.280) | 1.088 (0.930–1.271) |
| Bruckner neighboring index | | |
| Baseline | 0.974 (0.886–1.071) | 0.963 (0.871–1.064) |
| Change since baseline | 0.933 (0.869–1.003) | 0.948 (0.876–1.025) |
| Perceived community violence | | |
| Baseline | 1.088 (0.897–1.320) | 0.974 (0.775–1.224) |

| Characteristics of Participants and Census Tracts | Bivariate Models,* Odds ratio (95% CI) | Multivariable Model, AOR (95% CI) |
|---|---|---|
| Change since baseline | 1.113 (0.946,1.310) | 1.054 (0.875–1.269) |
| Data collection method‡ | 1.724 (0.650–4.569) | 1.244 (0.412–3.752) |
| Tract sex ratio for black adults (reference, equity) | | |
| Fewer men than women | 1.704 (0.779–3.728) | 1.687 (0.683–4.170) |
| More men than women | 1.002 (0.223–4.513) | 2.283 (0.439–11.873) |
| Percent of residents who have lived in the tract for <1 y | | |
| Baseline | 0.904 (0.0.857–0.953) | 0.920 (0.868–0.977) |
| Change since baseline | 1.010 (0.980–1.042) | 1.016 (0.981–1.052) |
| Tract density alcohol outlets (per sq mile) | | |
| Baseline | 0.951 (0.838–1.078) | 0.925 (0.855–1.00) |
| Change since baseline | 0.970 (0.925–1.018) | 0.965 (0.911–1.022) |
| Tract socioeconomic disadvantage component§ | | |
| Baseline | 1.657 (0.827–3.319) | 1.718 (0.908–3.249) |
| Change since baseline | 1.521 (1.093–2.115) | 1.551 (1.065–2.261) |

Relationships were modeled using HGLMs.

*Each bivariate model included the time covariates and the interaction with substance dependence.

†Marital status was excluded from the multivariable model because it was perfectly correlated with the outcome.

‡At waves 1 and 2, we gathered network data via an interviewer-administered survey; at waves 4 to 7, network items were asked via computer-administered personal interviewing methods; at wave 3, participants were randomized to one condition or the other.

§This component consists of median household income, unemployment rate, poverty rate, high school dropout rate, violent crime rate, and percent of residents who are black.