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People and places: relocating to neighborhoods with better economic and social conditions is associated with less risky drug/alcohol network characteristics among African American adults in Atlanta, GA

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Abstract

Background—Few studies assess whether place characteristics are associated with social network characteristics that create vulnerability to substance use.

Methods—This longitudinal study analyzed 7 waves of data (2009-2014) from a predominantly substance-using cohort of 172 African-American adults relocated from public housing complexes in Atlanta, GA, to determine whether post-relocation changes in exposure to neighborhood conditions were associated with four network characteristics related to substance use: number of social network members who used illicit drugs or alcohol in excess in the past six months (“drug/alcohol network”), drug/alcohol network stability, and turnover into and out of drug/alcohol networks. Individual-and network-level characteristics were captured via survey and administrative data were used to describe census tracts where participants lived. Multilevel models were used to assess relationships of census tract-level characteristics to network outcomes over time.

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Results—On average, participants relocated to census tracts that had less economic disadvantage, social disorder, and renter-occupied housing. Post-relocation reductions in exposure to economic disadvantage were associated with fewer drug/alcohol network members and less turnover into drug/alcohol networks. Post-relocation improvements in exposure to multiple census tract-level social conditions were associated with fewer drug/alcohol network members, less turnover into drug/alcohol networks, less drug/alcohol network stability, and more turnover out of drug/alcohol networks.

Conclusion—Relocating to neighborhoods with less economic disadvantage and better social conditions may weaken relationships with substance-using individuals.

Keywords

substance use; social networks; neighborhood characteristics; social epidemiology; longitudinal analysis; US

1. Introduction

African American adults report more severe substance use and mental health disorders than White adults (Chen and Jacobson, 2012; Gil et al., 2004). As compared to White adults, African American adults are also less likely to utilize drug treatment and are more likely to succumb to substance use-related outcomes including HIV/AIDS and other sexually transmitted infections [HIV/STIs] and hepatitis C (Des Jarlais et al., 2013; Liu et al., 2014; Spiller et al., 2015; Wells et al., 2001; Williams et al., 2013). In addition, African Americans are more likely to be incarcerated for illicit drug possession (Alexander, 2010).

Substance use is influenced by the composition of the social networks in which people are embedded and by the characteristics of the places where people reside (Bohnert et al., 2009; Cooper et al., 2013; Genberg et al., 2011; Latkin et al., 1999, 1995; Linas et al., 2015; Mennis and Mason, 2010; Sterk et al., 2014; Williams and Latkin, 2007). Research documenting these realities is supported by the social ecologic model (Bronfenbrenner, 1979), which describes how social networks, communities, cultures and policies – intersect with one another to influence health.

Racial differences in social networks and communities may contribute to disparities in substance use severity and related outcomes among African American and White adults. As a result of racial residential segregation, African Americans are more likely to be restricted to environments plagued by disinvestment and low economic opportunity (Pietila, 2010). These features have been described as instilling an “urban health penalty” that exacerbates and differentially influences the health of low-income African Americans in part by isolating them from social networks that promote social norms and provide social capital that protect against poor health behaviors (Andrulis, 1997; Fitzpatrick and LaGory, 2003; Wilson, 1997).

Few studies explore the complex interplay between social networks and neighborhood conditions among predominantly low-income African Americans. This analysis addresses this gap in the literature by assessing whether place characteristics influence a set of social

network characteristics that increase vulnerability to substance use among African-American adults relocating from public housing in Atlanta, Georgia.

1.1 Social networks and substance use

A large body of research, conducted among predominantly African American samples, suggests that higher proportions of substance-using members in social networks is related to frequent substance use (Bohnert et al., 2009; Latkin et al., 1995; Williams and Latkin, 2007), less cessation (Latkin et al., 1999), and less retention in drug treatment among current substance users (Davey et al., 2007). Having social network members who use substances has also been associated with sexual behaviors that increase the risk of acquiring HIV/STIs (Cooper et al., 2014a; Rudolph et al., 2013a).

Social network characteristics are posited to influence health behavior by facilitating exchange of information, social capital, and descriptive norms (e.g., perceptions of what other people do) and injunctive norms (e.g., perceptions of what other people believe is appropriate or not). These mechanisms have been shown to link social network characteristics to substance use among adults and adolescents (Latkin et al., 2013; Matto et al., 2007; Olumide et al., 2014; Tobin et al., 2014; Tucker et al., 2015). For example, alcohol use among African American men has been associated with observations of social network members' alcohol use and perceptions that social network members approve alcohol use (Tobin et al., 2014). Similarly, descriptive and injunctive norms have been associated with illicit drug use and risky sexual behaviors (Davey-Rothwell et al., 2013; Latkin et al., 2013; Tucker et al., 2015).

This line of research connecting social network characteristics to substance use typically evaluates social network characteristics under the assumption that social networks are fixed. Different people may join (e.g., turnover into) and leave (e.g., turnover out of) substance-using networks over time, however, and these dynamics may differentially influence health. For example, turnover out of drug networks has been associated with lower odds of HIV risk behaviors among people who inject drugs, while turnover into drug networks has been associated with higher odds of HIV risk behaviors (Costenbader et al., 2006).

1.2 Place and substance use

Economic and social conditions of neighborhoods have also been linked to substance use among predominantly low-income African Americans through several pathways. Specifically, low-income African Americans are disproportionately concentrated in economically deprived communities with inadequate housing and high rates of residential instability. These characteristics have been attributed with undermining social control and collective efficacy (Andrulis, 1997; Fitzpatrick and LaGory, 2003; Sampson et al., 1997; Wilson, 1997), which may otherwise prevent visible drug market activity and curtail disinvestment and the establishment of alcohol outlets (Fitzpatrick and LaGory, 2003; Sampson et al., 1997; Theall et al., 2009; Wilson, 1997). Exposure to drug market activity has been associated with substance use (Sherman et al., 2004; Sherman and Latkin, 2002) and abandoned housing and alcohol outlets provide settings where drug market activity can occur and other social interactions (e.g. sharing substances/drug paraphernalia) with

individuals who distribute illicit drugs, or use illicit drugs or alcohol in excess, are facilitated (Mennis and Mason, 2010; Spelman, 1993).

In addition, the experience of living in an economically-deprived and socially-disordered neighborhood may cause psychological distress, establish a sense of hopelessness that encourages substance use (Boardman et al., 2001; Latkin and Curry, 2003; Ross and Mirowsky, 2009), and increase perceptions that substance use and norms supporting substance use are prevalent (Davey-Rothwell et al., 2015). Lastly, limited mobility and stigma attached to economically deprived African American neighborhoods may hinder residents of these neighborhoods from accessing norms and social capital that discourage substance use and drug market activity (Crum et al., 1996; Fitzpatrick and LaGory, 2003; Mennis and Mason, 2010; Sterk et al., 2007; Wilson, 1997).

Although the pathways linking place characteristics to substance use include social network processes, research on substance use rarely assesses the relationships of place characteristics to social network “determinants” of substance use quantitatively (Latkin et al., 2007; Mennis and Mason, 2010; Rudolph et al., 2013b; Sterk et al., 2014).

1.3 Relocation and social networks

This longitudinal study uses data from a cohort of African American adults relocated from public housing complexes in Atlanta, GA, between 2008 and 2010, to assess the relationships of changes in exposure to neighborhood conditions to drug and alcohol network characteristics over time. These relocations occurred during the last round of federally funded public housing relocations in Atlanta, which sought to decentralize impoverished households from spatially concentrated and “severely-distressed” public housing complexes (e.g., in extreme disrepair and located in neighborhoods characterized by high levels of poverty and violent crime; Popkin et al., 2004). Residents were provided with Housing Choice Vouchers to relocate to rental properties owned by landlords who accepted Housing Choice Vouchers for the appropriate specifications (e.g., number of bedrooms, rental amount). Residents identified properties online or from property listings provided by the Housing Authority. The complexes that initially housed the residents were demolished and replaced with mixed-income housing and mixed-use development.

Residents relocated from public housing as a result of these strategies have been reported to experience negative and positive consequences. Although many residents encounter obstacles to finding housing in the private market and relocate to areas that provide them with modest improvements in neighborhood affluence and safety (Popkin et al., 2002b), these small improvements have been associated with improvements in health outcomes (Cooper et al., 2013, 2014b, 2014c). Similarly, while some studies suggest that residents lose positive social capital following relocation (Curley, 2009; Greenbaum et al., 2008; Popkin et al., 2002b), some also demonstrate that ties to “draining” neighbors (i.e., neighbors who frequently request aide without reciprocating, cause stress, and engage in “negative” lifestyles) may be fractured following relocation (Curley, 2009).

In this study, we determine whether relocating to neighborhoods with “better” economic and social conditions is associated with reductions in social network characteristics that increase

vulnerability to substance use. We seek to answer this research question by assessing the longitudinal associations of post-relocation changes in exposure to neighborhood characteristics with changes in the number of participants' social network members who use illegal drugs or alcohol in excess (i.e., “drug/alcohol network”), drug/alcohol network stability, turnover into drug/alcohol networks, and turnover out of drug/alcohol networks.

2. Methods

2.1 Study sample, recruitment, and retention

Participants were recruited from seven severely distressed public housing complexes in Atlanta, Georgia that were demolished between 2008 and 2010. Recruitment strategies were diverse. Community- and faith- based organizations located near the complexes distributed flyers to clients and parishioners; study staff recruited onsite; and participants were asked to refer other adults.

Participants were eligible if they were African American adults aged 18 years, resided in one of the seven public housing complexes slated for demolition, and did not reside with a current study participant. Because STIs and substance use were primary study outcomes, eligibility criteria stipulated that participants report sexual activity in the past year and non-probability based quota sampling was conducted to establish a sample with diverse substance use histories. One quarter of participants met criteria for drug/alcohol dependence; ½ reported misusing substances but were not dependent; and ¼ did not report illicit drug use in the past five years or any recent alcohol misuse.

Participants attended a baseline visit scheduled prior to relocation (wave 1) and six follow-up visits every nine months thereafter (waves 2-7). Participants received \$20 USD for participating at baseline. This incentive increased by \$5 at each subsequent wave. Intensive retention strategies maintained a low loss to follow-up, with 10.5% (N=18) lost between waves 1-7. On average, at the visit preceding their missed visit, the reported substance use network size and characteristics of the census tracts where participants lost to follow-up lived did not substantially differ from participants retained in analysis.

2.2 Data collection and Measures

At each wave, participant information was captured by audio computer-assisted self-interview (ACASI). Social network information was captured using a social network inventory that asked participants to name 15 social network members and describe their demographic and behavioral characteristics. The social network inventory was administered by trained interviewers at waves 1 and 2 and ACASI from waves 3-7. A variable was constructed to account for this change in data collection.

2.2.1 Outcome Variables: Network characteristics—Outcomes were four network characteristics: number of network members who used illegal drugs or alcohol in excess in the last 6 months (e.g., “drug/alcohol network”), stability of the drug/alcohol network, turnover into the drug/alcohol network, and turnover out of the drug/alcohol network. Drug and alcohol network data were pooled to increase analytic power.

Measures of stability, turnover-in, and turnover-out required linking network members across waves. For each participant, study staff compared the names and demographic information of participants' social network members across waves to determine wave-to-wave changes in drug/alcohol network composition. When network members were difficult to distinguish, staff contacted participants to retroactively confirm linkages. Drug/alcohol network stability was defined using the following equation (Rothenberg et al., 1998):

$$\text{Drug/alcohol network stability} = \frac{C}{A+B-C}$$

A= number of drug/alcohol network members at wave $t-1$

B= number of drug/alcohol network members at wave t

C= number of drug/alcohol network members common between $t-1$ and wave t

Stability ranges from 0 to 1, with 0 denoting complete instability and 1 denoting complete stability. Because drug/alcohol stability equaled zero for more than half of participants, drug/alcohol network stability was dichotomized with the reference category defined as stability= 0, and the comparison category defined as stability >0 and 1. Stability cannot be used to discern whether people are leaving or entering networks; thus separate measures of turnover into and out of drug/alcohol networks were measured. Turnover into the drug/alcohol network was defined as the number of new network members that entered drug/alcohol networks between wave $t-1$ and wave t . Turnover out of the drug/alcohol network was defined as the number of network members who left drug/alcohol networks between wave $t-1$ and wave t . Because stability and turnover measures of drug/alcohol networks require two time points, we have no baseline measures of these constructs.

2.2.2 Census-tract measures—Participants' home addresses were geocoded to 2010 census boundaries at each wave. Data from the US Census Bureau and the Longitudinal Tract Database were used to construct census tract-level measures of neighborhood conditions associated with substance use and social networks in prior literature: the proportion of residents living in poverty, median household income, educational attainment, residential instability (i.e., the proportion of residents that moved in the past year), proportion non-Hispanic Black residents, and proportion renter-occupied housing. Annual data from local police departments and the Georgia Department of Revenue were used to construct measures of violent crime rates and alcohol outlet density. Violent crime rates were the number of “Type 1” violent crime incidents as defined by the FBI Uniform Crime Report (i.e., murder, non-negligent manslaughter, forcible rape, aggravated assault, and robbery) per 1,000 residents. Alcohol outlet density was defined as the number of alcohol outlets per square mile licensed to sell alcohol for off-premises consumptions. Off-premise alcohol outlets are disproportionately concentrated in low income and racial/ethnic minority neighborhoods (Romley et al., 2007), and are associated with alcohol consumption and violence (Cunradi et al., 2012; Gruenewald and Remer, 2006; Gruenewald et al., 2014; Jennings et al., 2014).

Because economic measures, violent crime, and alcohol outlet density were highly correlated, principle components analysis (PCA) with orthogonal rotation was conducted to determine the dimensionality of these items. The PCA identified an economic disadvantage component, which included poverty, median household income, and educational attainment, and a social disorder component, which included alcohol outlet density and violent crime rates.

2.2.3 Individual-level characteristics—Several individual-level characteristics were considered in analysis; all were dichotomous unless otherwise noted. Gender was fixed at the first wave, and the following time-varying characteristics pertained to a six-month reporting period unless otherwise noted: marital status, age (continuous), employment, household income (ordinal), number of residential moves (continuous), moving to a different census tract since the last wave, substance use (e.g. use of illicit drugs or alcohol in excess), self-rated health (ordinal), and depressive symptoms (as measured by the CESD-20 scale). Perceived community violence was measured using a 5-item scale that captured how often participants believed the following events occurred in their neighborhood: fights with weapons; violent arguments among neighbors; gang fights; sexual assault; and theft (Sampson et al., 1997).

2.6 Analysis

The distributions of individual-, network and tract-level characteristics were described across waves and correlations among census tract characteristics were determined. The distributions of each outcome were also plotted to determine how time (in months) should be defined for each outcome in analysis. For drug/alcohol network size, time was defined by two variables: time to event (wave 2) and the quadratic of time to event. For drug/alcohol network stability, time was defined as time since wave 2 and time since wave 3. For turnover into drug/alcohol networks, time was defined as time since wave 2; time since wave 3; and time since wave 5. For turnover out of drug/alcohol networks, time was defined as time since wave 2 and time since wave 3.

Histograms of each outcome were also evaluated at every wave to determine how each outcome should be operationalized. Drug/alcohol network size had a binomial distribution (as a function of total network size); drug/alcohol network stability had a bernouilli distribution; turnover into drug/alcohol networks had a poisson distribution; and turnover out of drug/alcohol networks had a binomial distribution (as a function of drug/alcohol network size at t-1).

Perceived community violence and all census tract characteristics (“place characteristics”) were centered at their wave 1 values (e.g., “baseline values”), with one variable representing the wave 1 value and the other representing change since wave 1 (e.g., “change since baseline values”); the latter was treated as a time-varying characteristic of participants. Time-varying characteristics were lagged by one visit in analysis of drug/alcohol network stability and drug/alcohol network turnover measures to better align with the inclusion of two time points in these outcomes.

Separate series of multilevel models were used to evaluate the relationships of time, individual and place characteristics to each outcome. Modelling was done in three stages and random intercepts for participants and random slopes for time were included in models at each stage. Models assessing turnover into drug/alcohol networks controlled (and included random slopes) for drug/alcohol network size at t-1 in all models for that outcome. The first series of models were conducted for the drug/alcohol network size outcome. In Stage 1, we assessed the relationships of time to drug/alcohol network size, and whether gender or baseline substance use interacted with time to influence drug/alcohol network size at a p-value 0.10. In Stage 2, we assessed the relationships of each individual- and tract-level characteristic to drug/alcohol network size, while controlling for time or the time-gender/substance use interaction significant at a p-value 0.10 in Stage 1. In Stage 3, we assessed the relationship of change since baseline measures of place characteristics associated with drug/alcohol network size in Stage 2 at a p-value 0.10, controlling for the baseline measures of the selected place characteristics, time (or time-gender/substance use interactions significant at p-value 0.10 in Stage 1), age, gender, ACASI survey administration variable, and other participant characteristics associated with drug/alcohol network size at a p-value 0.05 in Stage 2. Regardless of significance in Stage 2, substance use was not included in Stage 3 because it was hypothesized to be mediator. The same process was repeated for the other three outcomes.

3. Results

3.1 Description of participants, their networks, and the census tracts where they lived

A total of 172 participants were enrolled. At baseline, the majority of participants were women (57%; Table 1), had a mean age of 43 years (SD=14.0 years), earned a mean income of \$9,849.40 (SD=\$8,732.99), and were unemployed (89.5%). Participants' income and employment status slightly improved over time. By design, a large percentage of participants used substances at baseline (82%); this percentage gradually declined from waves 2 to 5, and increased slightly thereafter. Across waves, mean total network size was constant over time and averaged 5 people. Total network stability increased over time, while turnover in and out decreased.

As a result of the housing relocations, participants moved from the 7 census tracts where their former housing complexes were located to 94 census tracts by wave 7 (Table 1). On average, these relocations brought participants to neighborhoods that had approximately 40% less economic disadvantage and violent crime. On average, participant gender and educational attainment, and employment, household income, self-reported health status and substance use at the prior wave were not significantly associated with changes in exposure to any place characteristics of interest. On average, older participants experienced lower reductions in exposure to the studied place characteristics.

3.2 Multilevel analyses

3.2.1 Drug/alcohol network size—Drug/alcohol network size declined initially and slightly increased over time (Table 2- Stage 1). In Stage 2, reduced exposure to economic disadvantage and violent crime was associated with smaller drug/alcohol networks (Table 2-

Stage 2: economic disadvantage: $b=0.19$, $p\text{-value} < 0.01$; violent crime: $b=7.63$, $p\text{-value}=0.03$). Participant household income and substance use were associated with larger drug/alcohol networks; age appeared protective.

In Stage 3, the relationship between reduced exposure to economic disadvantage and smaller drug/alcohol networks remained (Table 2- Stage 3: economic disadvantage: $b=0.18$, $p\text{-value}=0.01$). Because economic disadvantage and crime were correlated, the association of exposure to violent crime with drug/alcohol network size was assessed in a separate model and the association remained statistically significant (Table 2- Stage 3: $b=9.88$, $p\text{-value}=0.01$). When substance use was included in both models, neither the magnitude nor significance of the associations changed substantially (data not shown in tables: economic disadvantage: $b=0.14$, $p\text{-value}=0.03$; violent crime: $b=9.69$, $p\text{-value}=0.01$).

3.2.2 Drug/alcohol network stability—Drug/alcohol network stability decreased from waves 2 to 3, and increased thereafter (Table 3- Stage 1). In Stage 2, reduced perceived community violence was associated with less drug/alcohol network stability (Table 3: $b=0.20$, $p\text{-value}=0.03$). Reduced exposure to economic disadvantage was associated with less drug/alcohol network stability, but this association was marginally significant (Table 3: $b=0.34$, $p\text{-value}=0.06$). Substance use was the only participant characteristic associated with drug/alcohol network stability.

In Stage 3, the associations of reduced perceived community violence and reduced exposure to economic disadvantage with less drug/alcohol network stability decreased in magnitude and significance (Table 3: perceived community violence, $b=0.17$, $p\text{-value}=0.09$; economic disadvantage, $b=0.26$, $p\text{-value}=0.16$). These associations slightly changed when substance use was included in the model (perceived community violence: $b=0.13$, $p\text{-value}=0.17$; economic deprivation: $b=0.27$, $p\text{-value}=0.13$).

3.2.3 Turnover into drug/alcohol network—Turnover into drug/alcohol networks increased from waves 2 to 3, decreased from wave 3 to wave 4, and increased thereafter. These trends were more pronounced among participants who were not using substances at baseline (Table 4-Stage 1). In Stage 2, relationships of reduced exposure to economic disadvantage, residential instability, and renter-occupied housing to less turnover into drug/alcohol networks were marginally significant (Table 4: economic disadvantage: $b=0.14$, $p\text{-value}=0.06$; residential instability: $b=1.05$, $p\text{-value}=0.10$; renter-occupied housing: $b=0.61$, $p\text{-value}=0.08$). Participant household income was associated with turnover into drug/alcohol networks; age appeared protective.

Because renter-occupied housing was correlated with economic disadvantage and residential instability, it was evaluated in a separate model in Stage 3. The association between reduced exposure to economic disadvantage and less turnover into participants' drug/alcohol networks increased in magnitude and became statistically significant in Stage 3 (Table 4: $b=0.17$, $p\text{-value}=0.03$). The associations of reduced exposure to residential instability and renter-occupied housing with less turnover into drug/alcohol networks increased in magnitude in Stage 3, but these associations remained marginally significant (Table 4:

residential instability: $b=1.25$, $p\text{-value}=0.06$; Table 4: renter-occupied housing: $b=0.66$, $p\text{-value}=0.07$).

3.2.4 Turnover out of drug/alcohol network—Turnover out of drug/alcohol networks increased from waves 2 to 3, and decreased thereafter- this decrease was steeper among males as compared to females (Table 5- Stage 1). In Stage 2, reduced exposure to tract-level social disorder was associated with less turnover out of drug/alcohol networks, but this association was marginally significant (Table 5: $b=0.19$, $p\text{-value}=0.08$). A similar association was observed between violent crime and turnover out of drug/alcohol networks when violent crime was disaggregated into a separate component (Table 5: $b=10.36$, $p\text{-value}=0.08$). Reduced perceived community violence was associated with more turnover out of drug/alcohol networks; this association was marginally significant (Table 5: $b=-0.11$, $p\text{-value}=0.06$). Moving to a different census tract since the last wave was also associated with turnover out of drug/alcohol networks.

Because violent crime was included in the social disorder measure, the relationship of changes in exposure to these census tract conditions to turnover out of participants' drug/alcohol networks were assessed in separate models in Stage 3. The association between reduced exposure to social disorder and less turnover out of drug/alcohol networks remained marginally significant in Stage 3 (Table 5: $b=0.19$, $p\text{-value}=0.08$), but the relationship of reduced exposure to violent crime to less turnover out of drug/alcohol networks lost statistical significance (Table 5: $b=1.64$, $p\text{-value}=0.78$). The association between reduced perceived community violence and more turnover out of drug/alcohol networks remained marginally significant in Stage 3 (Table 5: $b=-0.12$, $p\text{-value}=0.06$).

4. Discussion

In this predominantly substance-using sample of African American adults relocated from public housing complexes, reduced exposure to census tract-level economic disadvantage was associated with smaller drug/alcohol networks and fewer network members entering participants' drug/alcohol networks over time. Reduced exposure to tract-level violence, residential instability, and renter-occupied housing, and reduced perceptions of community violence were associated with smaller drug/alcohol networks, less drug/alcohol network stability, fewer network members entering participants' drug/alcohol networks, and more network members leaving participants' drug/alcohol networks.

The associations of reduced exposure to economic disadvantage to fewer substance-using social network members and less turnover into drug/alcohol networks corresponds to research suggesting that relocating to more affluent neighborhoods is associated with reduced frequency of substance use (Cooper et al., 2013; Genberg et al., 2011). The lack of an association of economic disadvantage with turnover out of drug/alcohol networks suggests that changes in exposure to economic conditions did not greatly influence whether existing ties with substance users were broken or not.

Several mechanisms operating within a social-ecologic framework may act in concert or independently to explain the relationships of reduced exposure to economic disadvantage to

drug/alcohol network size and turnover into drug/alcohol networks. First, living in impoverished neighborhoods and lacking formal employment opportunities have been associated with individual-level substance use and participation in drug market activity (Crum et al., 1996; Sherman and Latkin, 2002; Williams and Latkin, 2007). Thus relocating to less economically deprived areas may reduce exposure to and involvement in drug market activity and limit new interactions with substance-using residents.

Additionally, participants in recovery or contemplating cessation may have sought new relationships with residents who were not using substances and housing in more affluent census tracts to support cessation or recovery (Bohnert et al., 2009). On average, participants who were not using substances in this study reported 45% less substance-using social network members than substance using participants. Future research should systematically explore the bidirectional pathways connecting neighborhood conditions, substance use, and social networks.

Similarly, relationships of reduced exposure to census tract-level violence to smaller drug/alcohol networks, and reduced exposure to perceived community violence to lower drug/alcohol network stability and more turnover out of drug/alcohol networks may result from reduced opportunities to interact with substance-using individuals and less norms supportive of substance use in these neighborhoods (Davey-Rothwell et al., 2015; Latkin et al., 2007). The counterintuitive association of reduced exposure to tract-level social disorder and less turnover out of drug/alcohol networks may relate to increased policing and incarceration in areas where violence is perceived to be high. This hypothesis requires additional investigation.

The potential for reduced exposure to renter-occupied housing and residential instability to protect against turnover into drug/alcohol networks may result from high homeownership and resident tenure in these neighborhoods, which may prevent new residents from moving into these neighborhoods (including those who are substance using) and establish high levels of collective efficacy (Lindblad et al., 2013; Sampson et al., 1997). Collective efficacy may prevent drug market activity, strengthen norms that discourage substance use and drug market activity, and limit new interactions with substance users. These explanations and those aforementioned assume participants' social network members, particularly those with histories of substance use reside in the same neighborhoods. Future studies are needed to determine the extent to which this occurs.

Several limitations should be considered when interpreting findings from this study. Because a sampling frame of substance-using residents was not available for the housing complexes, substance-using residents could not be randomly selected. Therefore, the findings from this study may not be generalizable to the broader sample of substance-using residents relocated from public housing. Many demographic characteristics (e.g., proportion of specific age groups, median household income) of this study's sample corresponds with a multi-site sample of residents relocated from public housing due to similar policies; see Supplementary Table 1³; Popkin et al., 2002a). In comparison to the multisite sample,

³Supplementary material can be found by accessing the online version of this paper at <http://dx.doi.org> and by entering doi...

however, this study's sample had a lower proportion of participants aged 25-34 years, higher proportion of participants aged 50-61 years, and smaller median household size. These differences may correspond to targeted sampling of households with children aged <15 years in the multi-site sample (Popkin et al., 2002a).

Second, we could not establish a comparison group of nonrelocators. All severely-distressed housing complexes were demolished in Atlanta, and residents of other complexes are predominantly disabled and elderly.

The social network data collected in this study were egocentric, thus participants' perceptions of networks members' substance use could not be confirmed by the social network members themselves. Additionally, while self-report of social network member's demographic attributes and provision of social support demonstrates good reliability and validity (Barrera, 1990; Hammer, 1990), measurement of the reliability and validity of perceived substance use among social network members is lacking. However, more than 80% of participants reported using substances with the drug/alcohol network members they nominated. This supports the assumption that participants correctly recalled their network members' behaviors. We could not determine whether response fatigue may have caused participants to report fewer network members over time, however. Lastly, analysis of time-varying confounders that may be affected by neighborhood conditions also limits causal interpretations of the relationships observed in this study.

Despite these limitations, this study suggests that improvements in exposure to neighborhood conditions reduces “risky” drug/alcohol network characteristics, independent of the influence of individual-level characteristics. This study extends research on the social epidemiology of substance use by demonstrating associations of place with four different attributes of social networks that have been less explored in the literature to date. Future studies should systematically determine whether changes in social networks mediate the relationships of improvements in neighborhood conditions to health, and extend this line of research to understand the health implications of neighborhood revitalization plans that do not cause mass relocations. Findings from this research can support future policies and community-based health interventions that empower low-income residents economically, reduce violence, strengthen resident tenure, and improve residents' perceptions of their communities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

This study includes the following

- Less economic disadvantage was associated with fewer drug/alcohol network members
- Less economic disadvantage was associated with less turnover into drug/alcohol networks
- Better social conditions were associated with fewer drug/alcohol network members
- Better social conditions were associated with less turnover into drug/alcohol networks
- Better social conditions were associated with more turnover out of drug/alcohol networks.

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Table 1
Distributions of participant, network, and census tract characteristics among 172 African American adults relocated from seven public housing complexes in Atlanta, GA, across 7 waves of follow-up

Characteristics ⁴	Wave 1 N(%) or Mean (SD)	Wave 2 N(%) or Mean (SD)	Wave 3 N(%) or Mean (SD)	Wave 4 N(%) or Mean (SD)	Wave 5 N(%) or Mean (SD)	Wave 6 N(%) or Mean (SD)	Wave 7 N(%) or Mean (SD)
Participant	N=171 ⁵	N=163	N=160	N=156	N=158	N=154	N=154
Age	42.9 (14.0)	43.1 (13.9)	43.2 (14.0)	43.5 (13.8)	46.4 (13.7)	46.8 (13.7)	47.2 (48.5)
Women ⁶	98 (57.0)	96 (58.9)	93 (58.1)	90 (57.7)	91 (57.6)	89 (57.8)	90 (58.4)
Married or cohabitating	16 (9.4)	16 (9.5)	15 (9.4)	15 (9.7)	17 (10.8)	15 (9.7)	14 (9.1)
Employed	18 (10.5)	20 (12.3)	30 (18.8)	24 (15.6)	30 (19.4)	23 (14.9)	30 (19.5)
Household income	\$9,849.4 (\$8,733.0)	\$10,473.9 (\$9,655.9)	\$11,217.1 (\$9,533.8)	\$9,966.2 (\$9,137.4)	\$11,013.5 (\$10,325.6)	\$11,672.4 (\$9,279.9)	\$13,918.9 (12,399.8)
Currently homeless	--	7 (4.3)	8 (5.0)	10 (6.5)	11 (7.0)	8 (5.2)	15 (9.7)
Number of times changed residence	--	1.1 (0.3)	0.4 (1.7)	0.2 (1.1)	0.5 (1.6)	0.6 (2.0)	0.5 (1.8)
Moved to different census tract since last	--	156 (95.7)	45 (27.6)	42 (26.1)	37 (23.0)	28 (17.6)	33 (21.4)
Incarcerated in jail/prison/	--	--	6 (3.75)	3 (1.92)	3 (1.91)	4 (2.60)	4 (2.6)
Mild depressive symptoms (CESD 20 score= 15-22)	45 (26.3)	42 (25.9)	47 (29.4)	31 (20.4)	35 (22.3)	36 (23.7)	32 (20.9)
Major depressive symptoms (CESD 20 score > 22)	48 (28.1)	27 (16.7)	19 (11.9)	23 (15.1)	32 (20.4)	23 (15.1)	25 (16.3)
Substance use	122 (81.9)	101 (63.5)	92 (58.6)	90 (58.1)	85 (54.5)	94 (62.3)	98 (64.1)
Perceived community violence	2.8 (2.2)	0.62 (1.1)	0.70 (1.2)	0.61 (1.0)	0.79 (1.3)	0.9 (1.4)	0.8 (1.5)
Network							
Total network size	5.8 (3.4)	5.5 (2.7)	5.1 (2.2)	5.3 (2.4)	5.3 (2.4)	5.1 (2.38)	5.1 (2.5)
Total network stability	--	0.52 (0.31)	0.45 (0.31)	0.58 (0.32)	0.77 (0.26)	0.78 (0.26)	0.81 (0.26)
Total network turnover-in	--	2.13 (2.23)	2.34 (2.18)	1.83 (2.10)	1.06 (1.59)	0.78 (1.48)	0.74 (1.72)
Total network turnover-out	--	2.51 (2.97)	2.74 (2.73)	1.73 (1.92)	0.99 (1.82)	1.10 (1.74)	0.69 (1.22)
Drug/alcohol network size	1.9 (2.2)	1.3 (1.8)	1.3 (1.5)	1.4 (1.8)	1.2 (1.7)	1.4 (1.8)	1.8 (2.1)
Drug network stability	--	0.2 (0.3)	0.2 (0.3)	0.2 (0.3)	0.3 (0.4)	0.3 (0.4)	0.3 (0.4)
Drug network turnover-in	--	0.7 (1.3)	1.0 (1.4)	1.0 (1.5)	0.6 (1.1)	0.8 (1.2)	1.0 (1.6)
Drug Network turnover-out	--	1.4 (1.8)	1.0 (1.7)	0.9 (1.2)	0.7 (1.3)	0.6 (1.2)	0.6 (1.1)

Characteristics ⁴	Wave 1 N(%) or Mean (SD)	Wave 2 N(%) or Mean (SD)	Wave 3 N(%) or Mean (SD)	Wave 4 N(%) or Mean (SD)	Wave 5 N(%) or Mean (SD)	Wave 6 N(%) or Mean (SD)	Wave 7 N(%) or Mean (SD)
Census tract							
Proportion of individuals in poverty	0.5 (0.1)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)	0.3 (0.1)
Median household income	\$15809.9 (\$4482.6)	\$33476.0 (\$15788.3)	\$33735.6 (\$15928.7)	\$33530.8 (\$17094.3)	\$34408.4 (\$16516.8)	\$33396.7 (\$15422.4)	\$32693.5 (\$15046.2)
Proportion of residents whose highest level of educational attainment is a high school diploma/GED	0.7 (0.1)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)
Violent crime rate (per 1000 residents)	35.6 (15.8)	20.7 (14.7)	20.9 (14.4)	20.7 (14.8)	21.3 (15.1)	21.6 (14.6)	21.1 (14.2)
Alcohol outlet density	9.3 (8.0)	6.4 (5.1)	6.3 (5.1)	6.7 (5.8)	6.7 (5.8)	6.6 (5.7)	6.2 (5.3)
Proportion non-Hispanic Black residents	0.8 (0.2)	0.7 (0.3)	0.7 (0.2)	0.7 (0.3)	0.7 (0.3)	0.7 (0.3)	0.8 (0.3)
Proportion renter-occupied housing	0.8 (0.2)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)
Residential instability	0.3 (0.1)	0.2 (0.1)	0.2 (0.1)	0.3 (0.1)	0.2 (0.1)	0.2 (0.1)	0.3 (0.1)

⁴ Participant characteristics are measured for a six month reporting period unless otherwise stated

⁵ Baseline survey data was lost for one participant

⁶ Women include 3 transgender women (i.e. male to female)

Table 2
Relationships of individual- and census tract-level characteristics to drug/alcohol network size among a sample of 172 African-American adults relocated from seven public housing complexes

Characteristics	Coefficient (p-value)				
	Stage 1 ⁷	Stage 2 ⁸	Stage 3a ⁹	Stage 3b ¹⁰	Stage 3b ¹⁰
Intercept	--	--	-0.04 (0.92)	-0.17 (0.62)	--
Time					
Time to event (relocation)	-0.03 (0.01)	--	-0.02 (<0.01)	-0.03 (<0.01)	--
Quadratic time to event	0.001 (<0.01)	--	0.001 (<0.01)	0.001 (<0.01)	--
Participant					
ACASI	--	0.22 (0.17)	0.15 (0.36)	0.17 (0.29)	--
Age	--	-0.03 (<0.01)	-0.03 (<0.01)	-0.03 (<0.01)	--
Baseline gender (ref=female)	--	-0.2 (0.37)	-0.02 (0.93)	-0.06 (0.75)	--
Married or cohabiting	--	0.10 (0.59)	--	--	--
Employed	--	-0.08 (0.56)	--	--	--
Household income	--	0.06 (0.01)	0.05 (0.04)	0.05 (0.06)	--
Number of times changed residence	--	0.02 (0.44)	--	--	--
Moved to different census tract since last wave	--	-0.18 (0.11)	--	--	--
Depressive symptoms (ref= CESD 20 score < 15)	--	--	--	--	--
Mild (CESD 20 score= 15-22)	--	-0.1 (0.37)	--	--	--
Major (CESD 20 score >22)	--	-0.1 (0.28)	--	--	--
Substance use	--	0.49 (<0.01)	--	--	--
Perceived community violence	--	--	--	--	--
Baseline	--	0.04 (0.40)	--	--	--
Change since baseline	--	0.02 (0.51)	--	--	--
Census tract					
Economic disadvantage	--	--	--	--	--
Baseline	--	0.12 (0.63)	-0.1 (0.70)	--	--
Change since baseline	--	0.19 (<0.01)	0.18 (0.01)	--	--

Characteristics	Coefficient (p-value)			
	Stage 1 ⁷	Stage 2 ⁸	Stage 3a ⁹	Stage 3b ¹⁰
Social disorder				
Baseline	--	-0.20 (0.09)	--	--
Change since baseline	--	-0.01 (0.76)	--	--
Violent crime rate (per 1000 residents)				
Baseline	--	-8.82 (0.35)	--	0.51 (0.94)
Change since baseline	--	7.63 (0.03)	--	9.88 (0.01)
Alcohol outlet density				
Baseline	--	-0.03 (0.10)	--	--
Change since baseline	--	-0.01 (0.43)	--	--
Proportion non-Hispanic Black residents				
Baseline	--	0.61 (0.48)	--	--
Change since baseline	--	0.03 (0.91)	--	--
Proportion renter-occupied housing				
Baseline	--	-2.54 (<0.01)	--	--
Change since baseline	--	0.29 (0.33)	--	--
Residential instability				
Baseline	--	-3.6 (0.04)	--	--
Change since baseline	--	0.36 (0.55)	--	--

Note: Drug/alcohol network size had a Binomial distribution. All variables were time-varying unless otherwise noted.

⁷ Stage 1 assessed the relationship of time to drug/alcohol network size, and whether gender or baseline substance misuse interacted with time to influence drug/alcohol network size. Non-significant interactions are not shown.

⁸ Stage 2 assessed the relationships of each participant and place characteristic to drug/alcohol network size, controlling for time.

⁹ Stage 3 assessed the relationship of "change since baseline" measures of place characteristics associated with drug/alcohol network size in Stage 2 at a p-value 0.10, controlling for the baseline measures of the selected place characteristics, time, age, gender, ACASI survey administration variable, and other participant characteristics associated with drug/alcohol network size at p 0.05 in Stage 2. Substance use was not included in Stage 3 because it was hypothesized to be a mediator.

¹⁰ To avoid multicollinearity, economic disadvantage and violent crime were evaluated in separate models in Stage 3.

Table 3
Relationships of individual- and census tract-level characteristics to drug/alcohol network stability among a sample of 172 African-American adults relocated from seven public housing complexes

Characteristics	Coefficient (p-value)		
	Stage 1/1	Stage 2/2	Stage 3/3
Intercept	--	--	0.13 (0.90)
Time			
Time since relocation	-0.05 (0.03)		-0.04 (0.35)
Time since wave 3	0.10 (<0.01)		0.08 (0.08)
Participant			
ACASI	--	0.57 (0.24)	0.73 (0.15)
Age	--	-0.02 (0.08)	-0.02 (0.19)
Baseline gender (ref=female)	--	-0.54 (0.18)	-0.31 (0.46)
Married or cohabiting	--	0.15 (0.78)	--
Employed	--	-0.28 (0.46)	--
Household income	--	0.04 (0.58)	--
Number of times changed residence	--	-0.004 (0.96)	--
Moved to different census tract since last wave	--	-0.30 (0.36)	--
Depressive symptoms (ref= CESD 20 score < 15)	--		
Mild (CESD 20 score= 15-22)	--	0.52 (0.16)	--
Major (CESD 20 score >22)	--	-0.37 (0.25)	--
Substance use	--	0.63 (0.05)	--
Perceived community violence			
Baseline	--	0.12 (0.27)	0.01 (0.94)
Change since baseline	--	0.20 (0.03)	0.17 (0.09)
Census tract			
Economic disadvantage			
Baseline	--	0.38 (0.27)	0.26 (0.48)
Change since baseline	--	0.34 (0.06)	0.26 (0.16)

Characteristics	Coefficient (p-value)		
	Stage 1 ^{1/1}	Stage 2 ^{1/2}	Stage 3 ^{1/3}
Social disorder			--
Baseline	--	-0.16 (0.37)	--
Change since baseline	--	-0.15 (0.36)	--
Violent crime rate (per 1000 residents)			--
Baseline	--	-1.52 (0.91)	--
Change since baseline	--	6.36 (0.51)	--
Alcohol outlet density			--
Baseline	--	-0.03 (0.38)	--
Change since baseline	--	-0.03 (0.32)	--
Proportion non-Hispanic Black residents			--
Baseline	--	1.4 (0.21)	--
Change since baseline	--	0.27 (0.66)	--
Proportion renter-occupied housing			--
Baseline	--	-1.02 (0.41)	--
Change since baseline	--	1.01 (0.23)	--
Residential instability			--
Baseline	--	-3.67 (0.19)	--
Change since baseline	--	-0.22 (0.90)	--

Note: Drug/alcohol network stability had a Bernoulli distribution. All variables were time-varying unless otherwise noted.

^{1/1} Stage 1 assessed the relationship of time to drug/alcohol network stability, and whether gender or baseline substance misuse interacted with time to influence drug/alcohol network stability. Non-significant interactions are not shown.

^{1/2} Stage 2 assessed the relationships of each participant and place characteristic to drug/alcohol network stability, controlling for time.

^{1/3} Stage 3 assessed the relationship of "change since baseline measures" of place characteristics associated with drug/alcohol network stability in Stage 2 at a p-value 0.10, controlling for the baseline measures of the selected place characteristics, time, age, gender, ACASI survey administration variable, and other participant characteristics associated with the drug/alcohol network stability at p 0.05 in Stage 2. Substance use was not included in Stage 3 because it was hypothesized to be a mediator.

Table 4
Relationships of individual-, network-, and census tract-level characteristics to turnover into drug/alcohol networks among a sample of 172 African-American adults relocated from seven public housing complexes

Characteristics	Coefficient (p-value)						
	Stage 1/4	Stage 2/5	Stage 3a/6	Stage 3b/7	Stage 3a/6	Stage 3b/7	Stage 3b/7
Intercept	--	--	-5.98 (<0.01)	-5.57 (<0.01)			
Time							
Time since relocation	0.11 (<0.01)	--	0.13 (<0.01)	0.12 (<0.01)			
Time since wave 3	-0.21 (<0.01)	--	-0.24 (<0.01)	-0.23 (<0.01)			
Time since wave 4	0.17 (<0.01)	--	0.17 (<0.01)	0.17 (<0.01)			
Participant							
ACASI	--	-0.04 (0.82)	-0.01 (0.96)	-0.02 (0.94)			
Age	--	-0.02 (0.01)	-0.02 (0.03)	-0.01 (0.15)			
Baseline gender (ref=female)	--	-0.25 (0.20)	-0.21 (0.29)	-0.20 (0.29)			
Married or cohabiting	--	-0.11 (0.60)	--	--			
Employed	--	0.19 (0.20)	--	--			
Household income	--	0.10 (<0.01)	0.11 (<0.01)	0.11 (<0.01)			
Number of times changed residence	--	0.02 (0.37)	--	--			
Moved to different census tract since last wave	--	0.08 (0.50)	--	--			
Depressive symptoms (ref= CESD 20 score < 15)							
Mild (CESD 20 score= 15-22)	--	0.18 (0.16)	--	--			
Major (CESD 20 score >22)	--	0.29 (0.06)	--	--			
Baseline substance use	5.42 (0.01)	--	5.03 (0.01)	5.10 (<0.01)			
Time since relocation * baseline substance use	-0.09 (0.01)	--	-0.09 (0.01)	-0.10 (<0.01)			
Time since wave 3 * baseline substance use	0.18 (<0.01)	--	0.18 (<0.01)	0.20 (<0.01)			
Time since wave 4 * baseline substance use	-0.14 (0.02)	--	-0.13 (0.03)	-0.13 (0.03)			
Substance use in last six months	--	0.06 (0.62)	--	--			
Perceived community violence							
Baseline	--	0.06 (0.20)	--	--			

Characteristics	Coefficient (p-value)			
	Stage 1 ^{1/4}	Stage 2 ^{1/5}	Stage 3a ^{1/6}	Stage 3b ^{1/7}
Change since baseline	--	0.02 (0.60)	--	--
Network				
Drug/alcohol network size	-0.18 (<0.01)	--	-0.19 (<0.01)	-0.20 (<0.01)
Census tract				
Economic disadvantage				
Baseline	--	-0.06 (0.74)	-0.16 (0.33)	--
Change since baseline	--	0.14 (0.06)	0.17 (0.03)	--
Social disorder				
Baseline	--	-0.22 (0.01)	--	--
Change since baseline	--	-0.10 (0.16)	--	--
Violent crime rate (per 1000 residents)				
Baseline	--	-8.35 (0.20)	--	--
Change since baseline	--	1.55 (0.70)	--	--
Alcohol outlet density				
Baseline	--	-0.03 (0.06)	--	--
Change since baseline	--	-0.01 (0.45)	--	--
Proportion Non-Hispanic Black residents				
Baseline	--	0.52 (0.35)	--	--
Change since baseline	--	0.37 (0.19)	--	--
Proportion rentier-occupied housing				
Baseline	--	-1.08 (0.08)	--	-0.81 (0.23)
Change since baseline	--	0.61 (0.08)	--	0.66 (0.07)
Residential instability				
Baseline	--	0.17 (0.90)	0.50 (0.71)	--
Change since baseline	--	1.05 (0.10)	1.25 (0.06)	--

Note: Turnover into drug/alcohol networks had a Poisson distribution. All variables were time-varying and lagged one visit unless otherwise noted.

^{1/4} Stage 1 assessed the relationship of time to turnover into drug/alcohol networks, controlling for drug/alcohol network size at the prior visit, and determined whether gender or baseline substance misuse interacted with time to influence turnover into drug/alcohol networks. Non-significant interactions are not shown.

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¹⁵ Stage 2 assessed the relationships of each participant, network, and place characteristic to turnover into drug/alcohol networks, controlling for the time-baseline substance use interaction and drug/alcohol network size at the prior visit.

¹⁶ Stage 3 assessed the relationship of “change since baseline measures” of place characteristics associated with turnover into drug/alcohol networks in Stage 2 at a p-value 0.10, controlling for the baseline measures of the selected place characteristics, the time-baseline substance use interaction, age, gender, drug/alcohol network size at the prior visit, ACASI survey administration variable, and other participant characteristics associated with turnover into drug/alcohol networks at p 0.05 in Stage 2. Substance use was not included in Stage 3 because it was hypothesized to be a mediator.

¹⁷ Because renter-occupied housing was correlated with economic disadvantage and residential instability, renter-occupied housing was evaluated in a separate model in Stage 3.

Table 5
Relationships of individual- and census tract-level characteristics to turnover out of drug/alcohol networks among a sample of 172 African-American adults relocated from seven public housing complexes

Characteristics	Coefficient (p-value)				
	Stage 1 ¹⁸	Stage 2 ¹⁹	Stage 3a ²⁰	Stage 3b ²¹	Stage 3b ²¹
Time					
Time since relocation	0.03 (0.03)	--	0.08 (0.01)	0.08 (0.01)	0.08 (0.01)
Time since wave 3	-0.07 (<0.01)	--	-0.11 (<0.01)	-0.11 (<0.01)	-0.11 (<0.01)
Individual					
ACASI	--	-0.64 (0.08)	-0.66 (0.08)	-0.69 (0.07)	-0.69 (0.07)
Age	--	-0.01 (0.30)	-0.003 (0.78)	-0.004 (0.70)	-0.004 (0.70)
Gender	0.33 (0.23)	--	0.27 (0.33)	0.32 (0.26)	0.32 (0.26)
Time since wave 3* gender	-0.03 (0.08)	--	-0.02 (0.19)	-0.02 (0.16)	-0.02 (0.16)
Married or cohabiting	--	0.10 (0.77)	--	--	--
Employed	--	0.18 (0.46)	--	--	--
Household income	--	-0.02 (0.72)	--	--	--
Number of times changed residence	--	0.09 (0.12)	--	--	--
Moved to different census tract since last wave	--	0.50 (0.01)	0.49 (0.02)	0.48 (0.02)	0.48 (0.02)
Depressive symptoms (ref= CESD 20 score < 15)					
Mild (CESD 20 score= 15-22)	--	0.17 (0.41)	--	--	--
Major (CESD 20 score >22)	--	-0.15 (0.51)	--	--	--
Substance use	--	-0.13 (0.52)	--	--	--
Perceived community violence					
Baseline	--	-0.02 (0.81)	-0.03 (0.70)	-0.03 (0.71)	-0.03 (0.71)
Change since baseline	--	-0.11 (0.06)	-0.12 (0.06)	-0.12 (0.06)	-0.12 (0.06)
Census tract					
Economic disadvantage					
Baseline	--	-0.04 (0.84)	--	--	--
Change since baseline	--	0.04 (0.71)	--	--	--

Characteristics	Coefficient (p-value)			
	Stage 1 ¹⁸	Stage 2 ¹⁹	Stage 3a ²⁰	Stage 3b ²¹
Social disorder				
Baseline	--	-0.02 (0.89)	0.04 (0.76)	--
Change since baseline	--	0.19 (0.08)	0.19 (0.08)	--
Violent crime rate (per 1000 residents)				
Baseline	--	-0.43 (0.96)	--	-2.82 (0.73)
Change since baseline	--	10.36 (0.08)	--	1.64 (0.78)
Alcohol outlet density				
Baseline	--	-0.01 (0.66)	--	--
Change since baseline	--	0.02 (0.22)	--	--
Proportion Non-Hispanic Black residents				
Baseline	--	-0.36 (0.58)	--	--
Change since baseline	--	0.09 (0.82)	--	--
Proportion renter-occupied housing				
Baseline	--	-1.12 (0.13)	--	--
Change since baseline	--	0.02 (0.97)	--	--
Proportion residential instability				
Baseline	--	0.09 (0.96)	--	--
Change since baseline	--	0.92 (0.38)	--	--

Note: Turnover out of drug/alcohol networks had a Binomial distribution. All variables were time-varying and lagged one visit unless otherwise noted.

¹⁸ Stage 1 assessed the relationship of time to turnover out of drug/alcohol networks, and whether gender or baseline substance misuse interacted with time to influence turnover out of drug/alcohol networks. Non-significant interactions are not shown.

¹⁹ Stage 2 assessed the relationships of each participant and place characteristic to turnover out of the drug/alcohol networks, controlling for the time-gender interaction.

²⁰ Stage 3 assessed the relationship of change since baseline measures of place characteristics associated with turnover out of the drug/alcohol networks in Stage 2 at a p-value 0.10, controlling for the baseline measures of the selected place characteristics, the time-gender interaction, age, ACASI survey administration variable, and other participant characteristics associated with turnover out of drug/alcohol networks at p 0.05 in Stage 2. Substance use was not included in Stage 3 because it was hypothesized to be a mediator.

²¹ Because violent crime was included in the social disorder measure, violent crime was evaluated in a separate model in Stage 3.