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ZIP code-level gentrification and inadequate housing are associated with homelessness among a large urban US sample of people who inject drugs

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Strengths and limitations

- Although homelessness has been associated with HIV, HCV, and related risk behaviors among people who inject drugs in multiple settings, few empirical studies investigate the relationships of place-level housing and economic characteristics to homelessness.
- This study fills gaps in prior research on homelessness by documenting associations of ZIP code-level gentrification and inadequate housing with homelessness among people who inject drugs in the United States.
- The cross-sectional design and targeted sampling strategy should be considered when interpreting the findings from this study.

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Abstract

Background
Housing instability has been associated with poor health outcomes among people who inject drugs (PWID). This study investigates associations of local-level housing and economic conditions with homelessness among a large urban sample of PWID, an underexplored topic to date.

Methods
PWID in this cross-sectional study were recruited from 19 large cities in the US as part of National HIV Behavioral Surveillance (NHBS). PWID provided self-reported information on demographics, behaviors, and life events. Homelessness was the primary outcome of this study and was defined as residing on the street, or in a shelter, single room occupancy hotel, or car; or temporarily residing with friends or relatives any time in the past year. Data on county-level rental housing unaffordability and ZIP code-level gentrification (e.g., index of percent increases in non-Hispanic white residents, household income, gross rent from 1990-2009), and current inadequate housing (i.e., index of percent of households lacking plumbing/kitchen facilities), and economic deprivation were measured using data from the US Census Bureau and Department of Housing and Urban Development. Multilevel models evaluated associations of local economic and housing characteristics to homelessness.

Results
Sixty percent (5,394/8992) of participants reported homelessness in the past year. Adjusted models demonstrated that PWID living in ZIP codes with higher levels of gentrification or inadequate housing had higher odds of past-year homelessness (gentrification: AOR=1.10, 95% CI=1.04, 1.15; inadequate housing: AOR=1.12, 95% CI = 1.04,1.15).

Conclusions
Evaluation of urban planning strategies to minimize negative implications of gentrification and increase access to adequate housing may reduce homelessness among PWID.

Introduction

Safe and stable housing has been deemed a key social determinant of health by public health bodies, including the World Health Organization and United States Department of Health and Human Services.[1,2] As described by Aidala and Sumartojo, *"unsafe and unstable housing conditions serve as the intermediary by which inequities in social and economic conditions and policies influence health"*.[3] Consistent with this perspective, housing remains a key structural factor targeted by global Health in All Policies approaches and domestic structural interventions (e.g., Housing Opportunity for People Living with AIDS (HOPWA)).[2,4]

Despite several public health bodies recognizing housing as an important health determinant and despite declines in the percent of homeless persons who were unsheltered in the United States from 40% in 2007 to 31% in 2014, a recent study by the Department of Housing and Urban Development (HUD) reported that on a single night in 2014 more than 578,000 people experienced homelessness.[5] This suggests that the United States is far from attaining its goal of ending homelessness.

People who inject drugs (PWID) are particularly vulnerable to homelessness.[6-14] Homelessness among PWID has dire consequences for their health. Homelessness has been associated with relapse among former injectors,[8,15,16] and among former and active injectors, homelessness has been associated with injection and sexual risk behaviors,[8,10,14,17-20] the transmission of infectious diseases[13], opiate overdose,[21] and lower rates of drug treatment enrollment and retention,[18,22-24] drug cessation [15,16,25], and antiretroviral adherence among those who are HIV positive.[26]

Evaluations of "Housing First" interventions further support the importance of stable housing among PWID.[17,27,28] These interventions provide housing to unstably housed individuals without requiring participants to first engage in drug or mental health treatment. Although most of these evaluations have not been conducted exclusively among PWID, those conducted among individuals with co-occurring disorders (e.g., mental illness and substance use) suggest that Housing First interventions improve housing stability, drug treatment retention, [27] health behaviors and health outcomes.[28,17]

The determinants of homelessness that have been identified among PWID and other populations in prior literature have largely been individual characteristics, including socio-demographic status, mental health status, history of substance use, HIV status, and social network characteristics.[9,17,29,30] With the exception of qualitative research,[18,31] most research has not explored the potential influence of local place-based factors on homelessness.

Homelessness has been hypothesized to result from several place-based factors, including unaffordable housing, economic deprivation, inadequate housing (e.g. lacking plumbing etc.) and overcrowding.[32-34] Homelessness has also been hypothesized to be a consequence of urban redevelopment and gentrification processes that may exacerbate law enforcement activity and cause landlords to intentionally disinvest in maintenance and repair of properties that ultimately get repurposed or demolished.[35-39] Urban redevelopment and gentrification may also reduce affordable housing stock by increasing rent and housing market value; increase demand for social services; and potentially cause the needs of marginalized groups to go unmet.[34-38,40-44] Empirical data are lacking, however, on the extent to which place-based factors relate to homelessness. One early study conducted among shelter residents in Philadelphia and New York City is among the few studies that have explored this line of research. This study demonstrated that the

majority of shelter residents reported prior addresses that were located in economically deprived neighborhoods. [32]

This current study provides a rare opportunity to advance knowledge of possible connections of place-based factors with homelessness among PWID by linking individual-level data on homelessness among a large community-based sample of PWID to administrative data on economic and housing conditions at ZIP code and county levels. Figure 1 presents a conceptual framework that outlines pathways through which key local characteristics may lead to homelessness among PWID based on prior literature discussed above.[8,9,17,29,30,32-34,36,40-43] Boxes with dashed borders denote characteristics that are not measured in the current study.

Figure 1. Conceptual framework linking local economic and housing factors to homelessness among people who inject drugs (PWID)

Methods

NHBS study sample

PWID were recruited by respondent-driven sampling (RDS) for the Centers for Disease Control and Prevention's 2009 National HIV Behavioral Surveillance (NHBS). NHBS sampling procedures have been described elsewhere.[45] Briefly, its 2009 PWID surveillance cycle was implemented in 20 MSAs with high AIDS prevalence in 2006.[46] Eligible participants included those who had not already participated in the 2009 cycle of NHBS; were ≥18 years; reported injection drug use in the past year; demonstrated evidence of injection (e.g., track marks); resided in an NHBS-eligible MSA; and provided oral consent. Participants enrolled at the San Juan-Bayamon site were excluded because administrative data on several place-based characteristics are not available for this MSA. A total of 9882 participants met eligibility criteria in the remaining 19 MSAs.

Analysis was restricted to 9,702 PWID who self-identified as Hispanic/Latino, non-Hispanic/Latino black, and non-Hispanic/Latino white.[47] Participants were excluded from the analytic sample if they had invalid/incomplete surveys (n=26); invalid or missing ZIP code information (n=499); were transgender persons who comprised too small a category to be analyzed (n=51); or were missing information on key covariates (n=134). The final analytic sample included 8992 participants.

Data collection and measures

Trained interviewers collected self-reported individual-level data on PWID, including demographics, behaviors, life events, and ZIP codes and counties where they resided using standardized questionnaires. Participants were assigned to MSAs and regions based on interview site. When possible, participants who reported homelessness at the time of their interview were assigned to the ZIP code where they reported they frequently slept. When participants lived in ZIP codes that crossed county lines they were assigned to the county where most participants living in that ZIP code reported residing (n=341).

The outcome, individual-level homelessness was defined as self-reported homelessness, or residing on the street, in a shelter, single room occupancy hotel, or car; or temporarily residing with friends or relatives at any time in the past 12 months.

ZIP- and county-level factors were selected based on the conceptual framework described above. Definitions and sources of these factors are detailed in Table 1. Factors were created using data from the 2009 HUD Picture of Subsidized Households and US

Census Bureau's 1990 Decennial Census and 2007-2011 American Community Survey (ACS). County-level factors were percent unaffordable rental units among low-income households (% occupied rental units where >= 35% of household income was spent on rent among low-income households, 2007-2011 ACS) and average number of months that applicants were on waiting lists for assisted housing (2009 Picture of Subsidized Households). ZIP code-level factors were economic deprivation (e.g., index of % residents in poverty, 2007-2011 ACS), gentrification between 1990 and 2009 (e.g., index of % increases in % non-Hispanic white residents and median household income, 1990 Decennial Census and 2007-2011 ACS), percent household crowding (percent of occupied housing units with >1.5 people per room, 2007-2011 ACS), and inadequate housing (index of % occupied housing units lacking plumbing or kitchen facilities, 2007-2011 ACS). The US Census Bureau defines housing units to be a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied. Group quarters (e.g., treatment centers, correctional facilities, and homeless shelters) are not defined as housing units.[48]

Individual-level covariates were also selected based on previous research and included age, gender, race and ethnicity, full-time employment, and self-reported HIV status (i.e., indeterminate/unknown, negative, positive) at the time of the interview, and self-reported personal annual income dichotomized at the median (>$5,000 USD vs ≤ $5,000 USD), daily injection, binge drinking, non-injection drug use, and having a main or casual sexual partner in the past year. Incarceration (i.e., held in a jail or prison for at least one day in the past year) was hypothesized to be a mediator of several pathways relating place-based factors to homelessness. Measures of mental health status, a well-established predictor of homelessness, were not measured in this study.

Ethics

The Institutional Review Boards (IRBs) of Emory University and each NHBS site and the CDC approved study protocols.

Analysis

The distributions of all characteristics were determined using descriptive statistics. To prevent possible multicollinearity, the correlations between place-based characteristics were assessed. Logistic multilevel analysis was used to assess bivariate and multivariable relationships of place-based factors to the odds of homelessness. Random intercepts were included for ZIP codes, counties, and MSAs. Multivariable analysis assessed the relationships of place-based factors significant ($p<0.05$) in bivariate analysis to the outcome, controlling for individual-level confounders, and ZIP code-level economic deprivation and county-level housing affordability. Based on prior research, gentrification was conceptualized as reducing economic deprivation, housing affordability, and inadequate housing. Gentrification was also hypothesized as increasing law enforcement practices that would increase the arrest of PWID and thereby increase the odds of homelessness. Thus if gentrification was significantly associated with homelessness, two multivariable analyses were conducted: one that included these potential mediators in analyses and one that did not. We also explored whether the relationships of place-based factors to homelessness differed among Latino, black, and white participants through stratified analysis.

Results

Place characteristics

Approximately 50% of participants resided in counties where there was at least 87% (25th and 75th percentiles: 80.06, 90.32) unaffordable rental units among low-income households and the average number of months that applicants were on waiting lists for assisted housing was 26 months (25th and 75th percentiles: 21, 38). Across ZIP codes where participants resided, the median inadequate housing score was 1.95 (25th and 75th percentiles: 1.53, 2.43). Specifically, on average, 2.25 percent of housing units lacked plumbing and 3.81 percent of housing units lacked kitchen facilities in ZIP codes that scored above the 50th percentile. The median gentrification score was 0.10 (25th and 75th percentiles: -0.45, 0.95) among the ZIP codes where participants lived. On average, ZIP codes that scored above the median were characterized by a 53% increase in percent of non-Hispanic white residents between 1990 and 2009, and a 20% increase in median gross rent and median household income (adjusted for inflation) between 1990 and 2009.

Participant characteristics

The majority of participants were black (52%) and male (72%). The median age of participants was 48 years (25th and 75th percentiles: 39, 54). Less than 5% of participants reported current full-time employment at the time of the interview and 61% earned an annual personal income of $5,000 USD or less. Sixty percent of participants reported experiencing homelessness at some point during the last year.

Associations of place characteristics with homelessness among PWID

In bivariate analysis (Table 3), PWID who lived in ZIP codes with higher levels of gentrification or inadequate housing had higher odds of homelessness in the past year (gentrification: Odds ratio (OR) =1.13 (95% Confidence Interval (CI) = 1.07, 1.18); inadequate housing: OR =1.13 (95% CI= 1.05, 1.22)).

Because economic deprivation, percent unaffordable rental units among low-income households and inadequate housing were hypothesized to mediate the relationship of gentrification to homelessness, two multivariable models were analyzed. Multivariable analysis would not converge when incarceration was included in the model. Thus it was excluded from multivariable analysis. The first multivariable model included gentrification; the second model included gentrification, economic deprivation, inadequate housing and percent unaffordable rental units among low-income households. In the first multivariable model, gentrification remained significantly associated with homelessness (AOR =1.12 (95% CI=1.06, 1.17)). The addition of economic deprivation, percent unaffordable rental units among low-income households, and inadequate housing to the multivariable model did not substantively alter the relationship between gentrification and the odds of homelessness (Table 3: AOR=1.10 (95% CI= 1.04, 1.15). Specifically, the odds of homelessness increased by 14% with each standard deviation increase in ZIP code-level gentrification. Inadequate housing also remained significantly associated with homelessness in multivariable analysis (Model 1: AOR=1.12 (95% CI=1.04, 1.20)). The odds of homelessness increased by 17% with each standard deviation increase in ZIP code-level inadequate housing. These associations did not differ in magnitude and significance across different racial/ethnic groups (data not shown). ZIP code-level economic deprivation and percent household crowding were not significantly associated with homelessness.

Discussion

A high level of homelessness (60% in last year) was reported among this large sample of people who inject drugs, which not only highlights PWID's vulnerability to poor health

outcomes but also raises concerns about the potential high societal costs that may result, including increased health care costs.[49] To our knowledge this is among the first studies to empirically reveal relationships of local economic and housing stock characteristics to homelessness among people who inject drugs. Specifically, this study discovered significant associations of ZIP code-level gentrification from 1990-2009 and current inadequate housing with homelessness among PWID; these relationships did not seem to vary across racial/ethnic groups. Because empirical investigations of the potential role of local economic and housing conditions to homelessness among the general population have been limited,[32] this paper also makes a new contribution to the larger body of research focused on homelessness and health.

This relationship between gentrification and homelessness is supported by prior qualitative studies with predominantly low-income and racial/ethnic minority residents, which suggests that living in gentrifying areas can increase housing instability. [31,36,40-43] These studies report a combination of pathways through which gentrification can increase housing instability. Gentrification is a change in the socioeconomic character of a community that is largely accompanied by stark inflations of rental costs and property taxes.[36,40,41] Housing markets of gentrifying areas may further be changed by direct demolition or repurposing of low-income and affordable housing units and shelters into mixed-income and mix-used development[31,35,36,40-43,50,51], a process that was widely implemented by federally-funded public housing demolitions in several US cities over the past two decades (e.g., Housing Opportunities for People Everywhere).[31,52]

Abrupt changes to the housing market in these ways can increase demand for affordable housing, shelters, and other safety-net services among low-to-moderate income residents who cannot afford inflated costs of living in gentrifying areas. As a result, the needs of the most marginalized and low-income groups, including PWID, may go unmet.[31,44,50,51] This is particularly concerning, given increasing rates of gentrification in several cities across the United States,[53] including those sampled in this study.

Contrary to prior conceptual frameworks and hypotheses, we did not observe a statistically significant association between unaffordable housing and homelessness in this study. These findings, however, may not challenge the importance of increasing access to affordable housing, and the potential positive health consequences that may result. Because the US Census Bureau's ACS does not provide publicly available data on households spending greater than 35% or more of their income on housing, we could not explore the potential impact of a higher threshold of affordability. Higher thresholds of 50% or more of income allocated to housing costs have been proposed by housing policy researchers to better measure the burden of housing-related costs among predominantly low-income populations.[54]

It is plausible that factors not measured in this study may partly contribute to the relationship between gentrification and homelessness. Prior research demonstrates that gentrification and its common antecedent- urban redevelopment- are associated with reductions in crime.[36,55] These reductions may result from increases in law enforcement strategies that aim to prevent drug-related offenses and other "public nuisances" that might slow redevelopment and gentrification processes.[35-37,44] Perceived crime, and political capital among new residents may further increase law enforcement activities in gentrifying areas. Prior studies suggest that (more affluent) residents moving into gentrifying areas often have greater political power than (predominately low-income and racial/ethnic minority) long term residents and are thereby more empowered in advocating for increased law enforcement [56-58] Together these circumstances can increase arrests of people who possess and use substances, including PWID, and thereby increase their vulnerability to homelessness.[8,59] Although we could not evaluate these

pathways in the current study, analysis demonstrated an association between self-reported arrests and homelessness, and post-hoc analysis demonstrated a moderate relationship between living in gentrifying ZIP codes and self-reported arrests among PWID in this study (OR= 1.04; CI= 1.00, 1.08).

The association of ZIP-code level inadequate housing to homelessness in this study is supported by prior theories that describe inadequate housing as the "last resort" for low-income residents who may subsequently seek space in shelters or other precarious settings that offer basic amenities.[33]

Inadequate housing can also predispose residents to eviction because inadequate housing units may lack consistent maintenance and may therefore be condemned by city agencies.[60] Substandard housing is also more likely to face abandonment and foreclosure, processes that increase housing instability among tenants.[32,61] Future longitudinal studies should explore these possibilities and the other suggested pathways through which inadequate housing and gentrification influence homelessness among PWID.

Limitations

This study is cross-sectional, so temporal associations that might be observed in longitudinal analysis may go undetected, and causal interpretations cannot be made. For example, the relationship of inadequate housing and homelessness may be bidirectional: inadequate housing increases homelessness among PWID, and homeless PWID may be more likely to seek housing in areas where inadequate housing is prevalent.

The cross-sectional design also limits exploration of potential displacement of homeless participants as a result of gentrification--prior studies have revealed links between gentrification, crime reduction efforts and the displacement of homeless persons and homeless services.[31,35] Additionally, findings may not be generalizable to PWID living outside of the MSAs captured by NHBS.

We did not account for clustering of observations within RDS chains because of the high number of intercepts required for cross-classified multilevel modelling. We adjusted for place and socio-demographic factors, however, which may have partially controlled for intra-chain clustering.[62,63] Additionally, we could not distinguish different types or durations of homelessness among participants in this study because these data are not collected by NHBS. Additionally, because we lacked data on specific policing strategies, we could not determine whether law enforcement increased and mediated the relationship of gentrification to homelessness.

Lastly, ZIP codes were the smallest geographic unit used to describe areas where participants resided. ZIP codes may not adequately capture smaller boundaries within which housing and economic factors are most relevant to housing stability among PWID.

Conclusion

Homelessness has been associated with the transmission of HIV/AIDS and HCV, and with lower levels of drug cessation among PWID, and with high societal costs. Identifying place-level predictors of homelessness can suggest changes in policy that can prevent these negative consequences. This study demonstrated relationships of current inadequate housing and gentrification from 1990-2009 to homelessness among PWID. Future longitudinal studies should explore whether these associations are causal, and identify potential mediators. Because this area of research has been underexplored

among the general population, future research should encompass the general population. Growth in this line of research can inform urban planning strategies and community mobilization campaigns designed to curb potential negative effects of gentrification and improve access to adequate housing among low-income and marginalized populations.

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Note: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention

Contributorship statement

S. L. Linton conceptualized, designed, and conducted the analysis. S. L. Linton constructed and compiled place-level data and interpreted the analysis and results. M. E. Kelley provided input on the analytic plan. M. E. Kelley, C. C. Karnes, Z. Ross, and M. E. Wolfe contributed to interpreting the geographical data, and S. Semaan, E. DiNenno, C. Sionean, C. Wejnert, and G. Paz-Bailey planned, designed, and oversaw data collection for NHBS. All authors contributed to revising the article and approved the final version of the article.

Competing interests

No competing interests to report

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Data sharing statement

No additional data available

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Table 1. Definition and sources of place-based exposures

Place characteristic	Measure	Source
County		
Percent unaffordable rental units among low-income households	Among households earning <$10,000 USD annually, the number of occupied rental units where residents spent >= 35% of their annual household income on rent, divided by the total number of households earning household income less than $10,000	2007-2011 American Community Survey
Average number of months that applicants were on waiting lists for assisted housing	Average months on waiting list among new admissions for Department of Housing and Urban Development assisted housing programs	2009 Picture of Subsidized Households , Department of Housing and Urban Development
ZIP code		
Percent household crowding	Percent of occupied housing units with >1.5 people per room	2007-2011 American Community Survey
Inadequate housing	An index was created by summing the square root of the percent of housing without plumbing and the square root of the percent of housing without kitchen facilities	2007-2011 American Community Survey
Economic deprivation[1]	Index of % residents employed in low-wage occupations (e.g. service, sales, construction, manufacturing, transportation), % households in poverty, % female-headed households with dependent children <18 years, % households on public assistance, % low-income households, % without high school diploma/GED, % unemployed	2007-2011 American Community Survey

[1] The economic deprivation index was informed by: Messer L, Laraia B, Kaufman J, et al. The development of a standardized neighborhood deprivation index. J Urban Health 2006;83:1041-62; Krieger N, Barbeau EM, Soobader M-J. Class matters: U.S. versus U.K. measures of occupational disparities in access to health services and health status in the 2000 U.S. National Health Interview Survey. International Journal of Health Services 2005;35:213-36. Principle components analysis (PCA) was conducted to confirm the dimensionality of the items across ZIP codes of all MSAs. Once confirmed through PCA, items were standardized by z-score, weighted by factor loadings, and summed to create the index.

Gentrification[2]	Index of percent change in the following indicators between 1990 and 2009: % poverty, % college or more among adults aged >= 25, % White, median household income, median monthly rent. Economic factors were adjusted for inflation using the Consumer Price Index.	Geolytics 1990 Long Form in 2010 Boundaries; 2007-2011 American Community Survey

Table 2. Distributions of ZIP code, county, and participant characteristics among 8,992 people who inject drugs living in 19 US metro areas in 2009

Characteristics	**Total** N (%) or Median (25^{th}, 75^{th})
	N= 8,992
Region	
Northeast	2,122 (23.55)
South	3,605 (40.01)
Midwest	938 (10.41)
West	2,345 (26.03)
MSA (N=19)	
County (N=51)	
Percent unaffordable rental units among low-income households	86.57 (80.06, 90.32)
Average number of months that applicants were on waiting lists for assisted housing	26 (21, 38)
ZIP code (N=939)	
Percent household crowding	1.5 (0.8, 2.8)
Inadequate housing	1.95 (1.53, 2.43)
Economic deprivation	2.26 (0.67, 3.87)
Gentrification	0.10 (-0.45, 0.95)
Participant characteristics	
Current age	48 (39, 54)
Male	6,450 (71.73)
Race/ethnicity	
Latino	1,622 (18.04)
Black	4,662 (51.85)
White	2,708 (30.12)
Annual income (≤5000 USD)	5,488 (61.03)
Full-time employment	394 (4.38)
Incarceration	3,281 (36.50)
Homelessness	5,394 (59.99)
Daily injection	2,310 (25.69)
Binge drinking	4,939 (54.93)

[2] The gentrification measure was informed by: Freeman L, Braconi F. Gentrification and displacement - New York City in the 1990s. Journal of the American Planning Association 2004;70:39-52.; Marcuse P. Gentrification, Abandonment, and Displacement: Connections, Causes, and Policy Responses in New York City. Journal of Urban and Contemporary Law 1985;28: 195–240.; Huynh M, Maroko AR. Gentrification and Preterm Birth in New York City, 2008-2010. J Urban Health 2013. Principle components analysis (PCA) was conducted to confirm the dimensionality of the items across ZIP codes of all MSAs. Once confirmed through PCA, items were standardized by z-score, weighted by factor loadings, and summed to create the index.

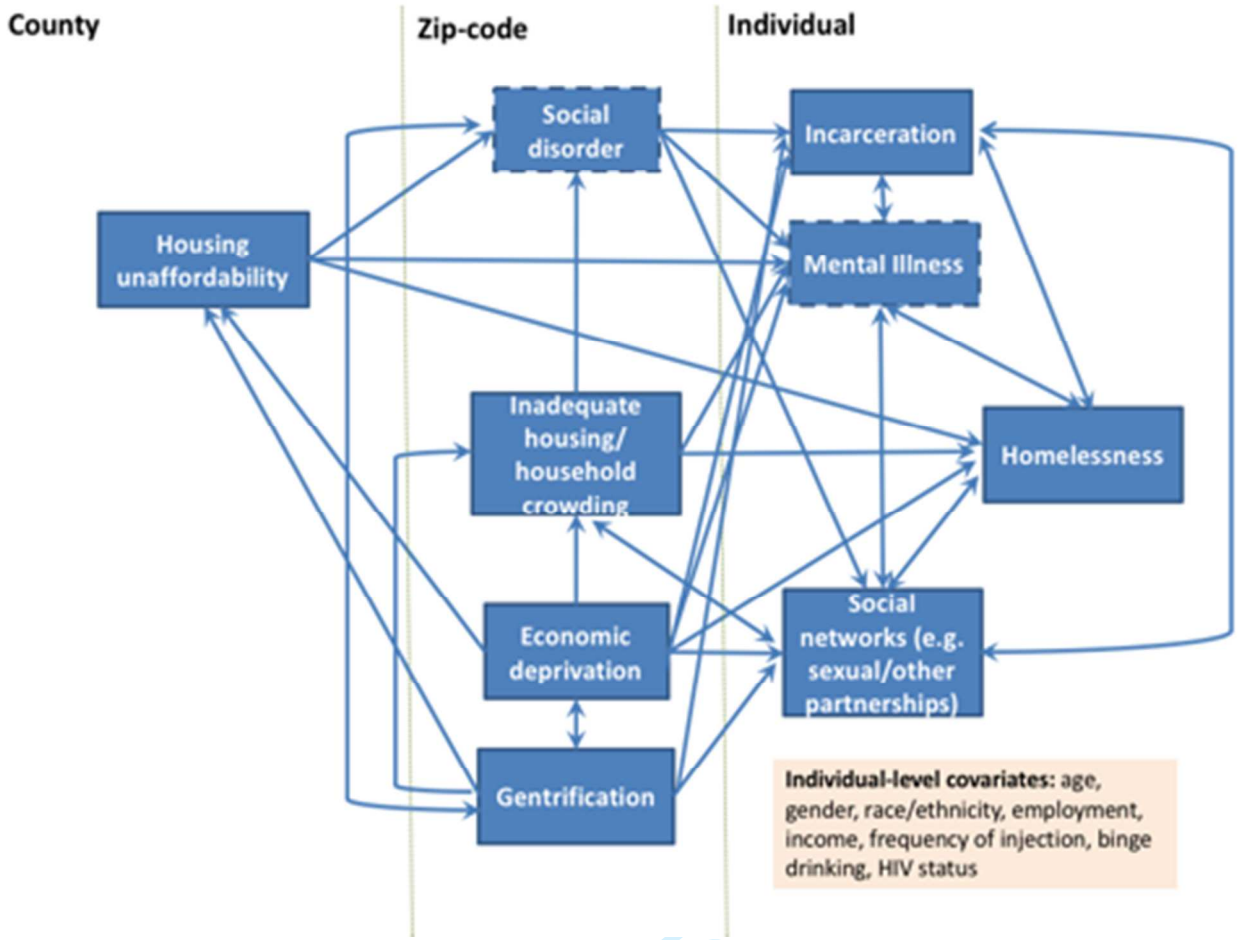
Type of sexual partner in the past 12 months	
Main	4,454 (49.53)
Casual	4,370 (48.60)
Non-injection drug use	6,765 (75.23)
Recent HIV test result	
Negative result on most recent HIV test	6,986 (77.69)
Positive result on most recent HIV test	495 (5.50)

Table 3. Association of ZIP code, county, and participant characteristics with recent homelessness among people who inject drugs from 19 US metro areas in 2009

	Odds ratio (95% Confidence interval)	Adjusted odds ratio (95% Confidence interval)*
Intercept		19.58 (1.13, 339.80)
Region		
Northeast (Reference)	1.00	
South	1.19 (0.73, 1.93)	--
Midwest	0.71 (0.33, 1.55)	--
West	1.33 (0.77, 2.28)	--
MSA (N=19)		
Random intercept variance	0.06 (0, 2.61)	0.06 (0, 2.00)
County(N=51)		
Random intercept variance	0.26 (0.10, 0.70)	0.21 (0.07, 0.69)
Percent unaffordable rental units among low-income households	0.97 (0.94, 1.01)	0.99 (0.95, 1.02)
Average number of months that applicants were on waiting lists for assisted housing	1.00 (0.98, 1.01)	--
ZIP code (N=937)		
Random intercept variance	0.31 (0.23, 0.43)	0.17 (0.11, 0.26)
Percent household crowding	1.08 (0.96, 1.21)	--
Inadequate housing	1.13 (1.05, 1.22)	1.12 (1.04, 1.15)
Economic deprivation	0.98 (0.95, 1.02)	0.99 (0.96, 1.03)
Gentrification	1.13 (1.07, 1.18)	1.10 (1.04, 1.15)
Participant Characteristics		
Current age	0.97 (0.96, 0.97)	0.97 (0.97, 0.98)
Sex (1=male)	0.88 (0.80, 0.98)	0.77 (0.69, 0.85)
Race/ethnicity		
White (reference)	1.00	1.00
Black	0.66 (0.58, 0.75)	0.74 (0.65, 0.86)
Latino	0.87 (0.75, 1.01)	0.81 (0.69, 0.95)
Annual income (5,000 USD vs. more)	0.48 (0.44, 0.53)	0.48 (0.44, 0.53)
Full-time employment	0.34 (0.27, 0.42)	0.38 (0.30, 0.48)
Incarceration	2.19 (1.98, 2.42)	--
Daily injection (vs. less than daily)	0.81 (0.73, 0.91)	0.83 (0.74, 0.93)
Binge drinking	1.51 (1.38, 1.66)	1.33 (1.20, 1.47)
Non-injection drug use	1.41 (1.27, 1.57)	1.27 (1.13, 1.42)

Type of sexual partner in the past 12 months		
None	1.00	1.00
Main	1.15 (0.82, 1.60)	1.14 (0.81, 1.60)
Casual	2.10 (1.91, 2.31)	1.80 (1.63, 1.99)
Recent self-reported HIV test result		
Indeterminate result/or did not receive result (reference)	1.00	1.00
Negative result	0.78 (0.69, 0.88)	0.88 (0.77, 1.00)
Positive result	0.49 (0.39, 0.62)	0.64 (0.50, 0.80)

* Multivariable analysis assessed the relationships of place-based factors significant ($p<0.05$) in bivariate analysis to the outcome, controlling for individual-level confounders, and ZIP code-level economic deprivation and county-level housing affordability. Because multivariate analysis did not converge with incarceration included in the model, it was removed from the model.



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Included in abstract on page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Page 3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Pages 4-5
Objectives	3	State specific objectives, including any prespecified hypotheses Page 5
Methods		
Study design	4	Present key elements of study design early in the paper Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants Page 5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pages 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Pages 5-6, 17-18 in Table 1
Bias	9	Describe any efforts to address potential sources of bias Page 9
Study size	10	Explain how the study size was arrived at Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pages 5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Page 6
		(*b*) Describe any methods used to examine subgroups and interactions Page 6
		(*c*) Explain how missing data were addressed Page 5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Page 7
		(*e*) Describe any sensitivity analyses N/A: None performed

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Page 5
		(b) Give reasons for non-participation at each stage Page 5
		(c) Consider use of a flow diagram Described in manuscript; no visual provided
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Page 7, 18-19
		(b) Indicate number of participants with missing data for each variable of interest Page 5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Page 7, 18-19
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Pages 6, 19-20
		(*b*) Report category boundaries when continuous variables were categorized Page 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A- no relative risk reported
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Pages 6, 8, and 10
Discussion		
Key results	18	Summarise key results with reference to study objectives Pages 7-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pages 7-10
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 9
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Cross-sectional association between ZIP code-level gentrification and homelessness among a large community-based sample of people who inject drugs in 19 US cities

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Cross-sectional association between ZIP code-level gentrification and homelessness among a large community-based sample of people who inject drugs in 19 US cities

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Cross-sectional association between ZIP code-level gentrification and homelessness among a large community-based sample of people who inject drugs in 19 US cities

Abstract

Background
Housing instability has been associated with poor health outcomes among people who inject drugs (PWID). This study investigates associations of local-level housing and economic conditions with homelessness among a large sample of PWID, an underexplored topic to date.

Methods
PWID in this cross-sectional study were recruited from 19 large cities in the US as part of National HIV Behavioral Surveillance (NHBS). PWID provided self-reported information on demographics, behaviors, and life events. Homelessness was defined as residing on the street, or in a shelter, single room occupancy hotel, or car; or temporarily residing with friends or relatives any time in the past year. Data on county-level rental housing unaffordability and demand for subsidized housing units, and ZIP code-level gentrification (e.g., index of percent increases in non-Hispanic white residents, household income, gross rent from 1990-2009) and economic deprivation were measured using data from the US Census Bureau and Department of Housing and Urban Development. Multilevel models evaluated associations of local economic and housing characteristics to homelessness.

Results
Sixty percent (5,394/8,992) of participants reported homelessness in the past year. The multivariable model demonstrated that PWID living in ZIP codes with higher levels of gentrification had higher odds of past-year homelessness (gentrification: Adjusted odds ratio=1.11, 95% Confidence Interval=1.04, 1.17).

Conclusions
Additional research is needed to determine the mechanisms through which gentrification increases homelessness among PWID to develop appropriate community-level interventions.

Strengths and limitations

- This study addresses gaps in prior literature by investigating the relationships of ZIP code-level economic deprivation and gentrification, and county-level unaffordable rental housing and demand for public housing, to homelessness.
- The cross-sectional design and targeted sampling strategy should be considered when interpreting the results from this study.

Introduction

Safe and stable housing has been deemed a key social determinant of health by public health bodies, including the World Health Organization and United States Department of Health and Human Services.[1,2] As described by Aidala and Sumartojo, *"unsafe and unstable housing conditions serve as the intermediary by which inequities in social and economic conditions and policies influence health"*.[3] Consistent with this perspective, housing remains a key structural factor targeted by global Health in All Policies approaches and domestic structural interventions (e.g., Housing Opportunity for People Living with AIDS (HOPWA)).[1,4]

Despite declines in percentages of unsheltered homeless persons in the United States from 40% to 31% between 2007 and 2014, a recent study by the Department of Housing and Urban Development (HUD) reported that on a single night in 2014 more than 578,000 people experienced homelessness.[5] This suggests that the United States is far from attaining its goal of ending homelessness.

People who inject drugs (PWID) are particularly vulnerable to homelessness.[6-14] Homelessness among PWID has dire consequences for their health. Homelessness has been associated with relapse among former injectors,[8,15,16] and among former and active injectors, homelessness has been associated with injection and sexual risk behaviors,[8,10,14,17-20] the transmission of infectious diseases[13], opiate overdose,[21] and lower rates of drug treatment enrollment and retention,[18,22-24] drug cessation [15,16,25], and antiretroviral adherence among those who are HIV positive.[26]

Evaluations of "Housing First" interventions further support the importance of stable housing among PWID.[17,27,28] These interventions provide housing to unstably housed individuals without requiring participants to first engage in drug or mental health treatment. Although most of these evaluations have not been conducted exclusively among PWID, those conducted among individuals with co-occurring disorders (e.g., mental illness and substance use) suggest that Housing First interventions improve housing stability, drug treatment retention, [27] health behaviors and health outcomes.[28,17]

The determinants of homelessness that have been identified among PWID and other populations in prior literature have largely been individual characteristics, including socio-demographic factors, mental health status, history of substance use, HIV status, and social network characteristics.[9,17,29,30] With the exception of qualitative research,[18,31] most research has not explored the potential influence of local place-based factors on homelessness.

Homelessness has been hypothesized to result from several place-based factors, including unaffordable housing and economic deprivation. Homelessness has also been hypothesized to be a consequence of urban redevelopment and gentrification processes that may cause landlords to intentionally disinvest in maintenance and repair of properties that ultimately get repurposed or demolished and thereby reduce available affordable housing stock.[32-36] Similarly, the demolition of public housing complexes that occurred under the Housing Opportunities for People Everywhere policy in several cities, may have contributed to the loss of affordable housing stock. Urban redevelopment and gentrification may also reduce affordable housing stock by increasing rent and housing market value; increasing demand for supportive housing and housing subsidies (e.g., Section-8 vouchers); and potentially causing the needs of marginalized groups to go unmet.[32-35,37-42]

Empirical data is lacking, however, on the extent to which place-based factors relate to homelessness. One early study conducted among shelter residents in Philadelphia and New York City is among the few studies that have explored this line of research. This study demonstrated that the majority of shelter residents reported prior addresses that were located in economically deprived neighborhoods. [43]

This current study provides a rare opportunity to further advance knowledge about the possible impacts of place-based factors on homelessness among PWID, by linking individual-level data on homelessness among a large community-based sample of PWID to administrative data on economic and housing conditions at ZIP code and county geographical levels. Increasing empirical evidence of the potential role of place-based factors on homelessness- above and beyond individual-level factors- may suggest potential structural interventions that should be implemented and reduce social stigma.[44]

Methods

NHBS study sample

PWID were recruited by respondent-driven sampling (RDS) for the Centers for Disease Control and Prevention's 2009 National HIV Behavioral Surveillance (NHBS). NHBS sampling procedures have been described elsewhere.[45] Briefly, its 2009 PWID surveillance cycle was implemented in 20 metropolitan statistical areas (MSAs) with high AIDS prevalence in 2006.[46] Eligible participants included those who had not already participated in the 2009 cycle of NHBS; were ≥18 years; reported injection drug use in the past year; demonstrated evidence of injection (e.g., track marks); resided in an NHBS-eligible MSA; and provided oral consent. Participants enrolled at the San Juan-Bayamon site were excluded because administrative data on several place-based characteristics were not available for this MSA. A total of 9,882 participants met eligibility criteria in the remaining 19 MSAs.

Analysis was restricted to 9,702 PWID who self-identified as Hispanic/Latino, non-Hispanic/Latino black, and non-Hispanic/Latino white.[47] Participants were excluded from the analytic sample if they had invalid/incomplete surveys (n=26); invalid or missing ZIP code information (n=499); were transgender persons who comprised too small a category to be analyzed (n=51); or were missing information on key covariates (n=134). The final analytic sample included 8,992 participants. Those excluded from analysis were more likely to be white (>10% difference) and live in the Western region of the US and less likely to live in the Midwestern region than those included in the analytic sample. Other characteristics measured in this study were not substantially different (>10%) between those included and excluded from analysis.

Data collection and measures

Trained interviewers collected self-reported individual-level data on PWID, including demographics, behaviors, life events, and ZIP codes and counties where they resided using standardized questionnaires. Participants were assigned to MSAs and regions based on interview site. When possible, participants who reported homelessness at the time of their interview were assigned to the ZIP code where they reported they frequently slept. When participants lived in ZIP codes that crossed county lines they were assigned to the county where most participants living in that ZIP code reported residing (n=341).

Individual-level homelessness was defined as self-reported homelessness, or residing on the street, in a shelter, single room occupancy hotel, or car; or temporarily residing with friends or relatives at any time in the past 12 months.

ZIP- and county-level factors were selected based on the conceptual framework described below (Figure 1). [8,9,17,29,30,33,37-41,43,48] Definitions and sources of these factors are detailed in Table 1. Factors were created using data from the 2009 HUD Picture of Subsidized Households and US Census Bureau's 1990 Decennial Census and 2007-2011 American Community Survey (ACS). County-level factors were percent unaffordable rental units[49] among low-income households and average number of months that applicants were on waiting lists for assisted housing. ZIP code-level factors were economic deprivation[50,51] and gentrification[38,40,52,53] between 1990 and 2009.

Individual-level covariates were also selected based on previous research [8,9,17,29,30,33,37-41,43,48]and included age, gender, race and ethnicity, full-time employment, and self-reported HIV status (i.e., indeterminate/unknown, negative, positive) at the time of the interview, and self-reported personal annual income dichotomized at the median (>$5,000 USD vs ≤ $5,000 USD), daily injection, binge drinking, non-injection drug use, having a main or casual sexual partner in the past year, and incarceration (i.e., held in a jail or prison for at least one day in the past year). Measures of poor mental health status, well-established predictors of homelessness, were not collected as part of NHBS.

Ethics

The Institutional Review Boards (IRBs) of Emory University and each NHBS site and the CDC approved study protocols.

Statistical Analysis

The distributions of all characteristics were determined using descriptive statistics (i.e., frequencies and percentages, and means and standard deviations). To prevent possible multicollinearity, the correlations between place-based characteristics were assessed. Univariate and multivariable multilevel logistic regression models were used to assess relationships of place-based factors to the odds of homelessness. Random intercepts were included for ZIP codes, counties, and MSAs. A multivariable model assessed the relationships of place-based factors significant at p-value<0.20 in univariate models to homelessness, controlling for individual-level covariates. We also explored whether the relationships of place-based factors to homelessness differed among Latino, black, and white participants through stratified analysis. Stata version 13 (StataCorp LP, College Station, TX).

Results

Place characteristics

On average, participants resided in counties where 85.18% (standard deviation (SD)=6.15) of rental units among low-income households were unaffordable and the average number of months that applicants were on waiting lists for assisted housing was 30.03 months (SD=17.65-Table 2). The mean gentrification score was 0.41 (1.45) among the ZIP codes where participants lived. On average, ZIP codes that scored above the mean were characterized by a 53% increase in percent of non-Hispanic white residents between 1990 and 2009, and a 20% increase in median gross rent and median household income (adjusted for inflation) between 1990 and 2009.

Participant characteristics

The majority of participants were black (52%) and male (72%- Table 2). The mean age of participants was 45.76 years (10.54). Less than 5% of participants reported current full-time employment at the time of the interview and 61% earned an annual personal income of $5,000 USD or less. Sixty percent of participants reported experiencing homelessness at some point during the last year.

Associations of place characteristics with homelessness among PWID

In univariate models (Table 3), PWID who lived in ZIP codes with higher levels of gentrification had a significantly higher odds of homelessness in the past year (Odds ratio=1.13; 95% Confidence interval= 1.07, 1.18). PWID who lived in counties with greater percentages of unaffordable rental housing units among low-income households were less likely to report homelessness in the past year; this association was marginally significant (Odds ratio=0.97; 95% Confidence interval=0.94, 1.01; p-value=0.110). These associations did not substantially differ in magnitude and significance across different racial/ethnic groups of PWID (data not shown).

In the multivariable model, ZIP code-level gentrification remained significantly associated with homelessness (Table 3: Adjusted odds ratio=1.11; 95% Confidence interval= 1.04, 1.17). Specifically, the odds of homelessness increased by 17% with each standard deviation increase in ZIP code-level gentrification. The association between percentages of unaffordable rental housing units among low-income households and homelessness was no longer marginally significant (Adjusted odds ratio=0.99; Confidence interval=0.96, 1.02).

Discussion

A high level of homelessness (60% in last year) was reported among this large sample of people who inject drugs, which not only highlights PWID's vulnerability to poor health outcomes but also raises concerns about the potential high societal costs that may result from homelessness, including increased health care costs.[54] To our knowledge this is among the first studies to empirically reveal relationships of local economic and housing stock characteristics to homelessness among people who inject drugs. Specifically, this study discovered a significant association between ZIP code-level gentrification from 1990-2009 and homelessness among PWID; this relationship did not vary across racial/ethnic groups. Because empirical investigations of the potential role of local economic and housing conditions to homelessness among the general population have been limited,[43] this paper also makes a new contribution to the larger body of research focused on homelessness and health.

The relationship between gentrification and homelessness in this analysis is supported by prior qualitative studies with predominantly low-income and racial/ethnic minority residents, which suggests that living in gentrifying areas can increase housing instability.[31,33,38-41] These studies report a combination of pathways through which gentrification can increase housing instability. Gentrification is a change in the socioeconomic character of a community that is largely accompanied by stark inflations of rental costs and property taxes.[33,38,39] Housing markets of gentrifying areas may further be changed by direct demolition or repurposing of low-income and affordable housing units into mixed-income and mix-used development[31-33,38-41,55,56], a process that was widely implemented

by federally-funded public housing demolitions in several US cities (e.g., Housing Opportunities for People Everywhere).[31,57]

Abrupt changes to the housing market in these ways can increase demand for affordable housing, shelters, and other safety-net services among low-to-moderate income residents who cannot afford inflated costs of living in gentrifying areas. As a result, the needs of the most marginalized and low-income groups, including PWID, may go unmet.[31,42,55,56] This is particularly concerning, given increasing rates of gentrification in several cities across the United States,[58] including those sampled in this study.

Contrary to prior conceptual frameworks and hypotheses, we did not observe a statistically significant association between unaffordable housing and homelessness in this study. These findings, however, may not challenge the importance of increasing access to affordable housing and the potential positive health consequences that may result from such efforts. Because the US Census Bureau's ACS does not provide publicly available data on low-income households spending greater than 35% or more of their income on housing, we could not explore the potential impact of a higher threshold of affordability. Higher thresholds of 50% or more of income allocated to housing costs have been proposed by housing policy researchers to better measure the burden of housing-related costs among predominantly low-income populations.[59] The measure of subsidized housing units that we used in this study is also limited and may not accurately reflect demand for subsidized housing. In many cities, waiting lists for subsidized housing are closed to applicants at specific thresholds and thus exclude the waiting times of those who could not apply.

It is plausible that factors not measured in this study may partly contribute to the relationship between gentrification and homelessness. Prior research demonstrates that gentrification and its common antecedent- urban redevelopment- are associated with reductions in crime.[33,60,61] These reductions may result from increases in law enforcement strategies that aim to prevent drug-related offenses and other "public nuisances" that might slow redevelopment and gentrification processes.[32-34,42] Perceived crime, and political capital among new residents may further increase law enforcement activities in gentrifying areas. Prior studies suggest that (more affluent) residents moving into gentrifying areas often have greater political power than (predominately low-income and racial/ethnic minority) long-term residents and are thereby more empowered in advocating for increased law enforcement [52,62,63] Together these circumstances can increase arrests of people who possess and use substances, including PWID, and thereby increase their vulnerability to homelessness.[8,64]

Limitations

This study is cross-sectional, so temporal associations that might be observed in longitudinal analysis may go undetected, and causal interpretations cannot be made. The cross-sectional design also limits exploration of potential displacement of homeless participants as a result of gentrification. Prior studies have revealed links between gentrification, crime reduction efforts, and the displacement of homeless persons and homeless services.[31,32] Additionally, findings may not be generalizable to PWID living outside of the MSAs captured by NHBS and the extent to which RDS generated a representative sample in this study cannot be confirmed.[65]

We did not account for clustering of observations within RDS chains because of the high number of intercepts required for cross-classified multilevel modelling. We adjusted for place and socio-demographic factors, however, which may have partially controlled for intra-chain clustering.[66,67] Additionally, we could not distinguish different types or

durations of homelessness among participants in this study because these data are not collected by NHBS.

Lastly, ZIP codes were the smallest geographic unit used to describe areas where participants resided. ZIP codes may not adequately capture smaller boundaries within which housing and economic factors are most relevant to housing stability among PWID.

Conclusion

Homelessness has been associated with the transmission of HIV/AIDS and HCV and lower levels of drug cessation among PWID and high societal costs. Identifying place-level predictors of homelessness can suggest changes in policy that can prevent these negative consequences. This study demonstrated a relationship between gentrification and homelessness among PWID. Future longitudinal studies should explore whether these associations are causal and identify potential mediators. Because this area of research has been underexplored among the general population, future research should include broader samples of residents. Growth in this line of research can inform urban planning strategies and community mobilization campaigns that are designed to curb the potential negative effects of gentrification by strengthening access to stable and permanent housing among low-income and marginalized populations.

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Note: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention

Contributorship statement

S. L. Linton conceptualized, designed, and conducted the analysis. S. L. Linton constructed and compiled place-level data and interpreted the analysis and results. M. E. Kelley and H. L. F. Cooper provided input on the analytic plan. M. E. Kelley, C. C. Karnes, Z. Ross, and M. E. Wolfe contributed to interpreting the geographical data, and S. Semaan, E. DiNenno, C. Sionean, C. Wejnert, and G. Paz-Bailey planned, designed, and oversaw data collection for NHBS. S. L. Linton, H. L. F. Cooper, M. E. Kelley, C. C. Karnes, Z. Ross, M. E. Wolfe, S. R. Friedman, D Des Jarlais, S. Semaan, B. Tempalski, C. Sionean, E. DiNenno, C. Wejnert, G. Paz-Bailey contributed to revising and finalizing the manuscript.

Competing interests

No competing interests to report

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Data sharing statement

No additional data available

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Figure 1. Conceptual framework linking local economic and housing factors to homelessness among people who inject drugs (PWID) [8,9,17,29,30,33,37-41,43,48]

Table 1. Definition and sources of place-based exposures

Place characteristic	Measure	Source
County		
Percent unaffordable rental units among low-income households	Among households earning <$10,000 USD annually, the number of occupied rental units[1] where residents spent >= 35% of their annual household income on rent, divided by the total number of households earning household income less than $10,000	2007-2011 American Community Survey
Average number of months that applicants were on waiting lists for assisted housing	Average months on waiting list among new admissions for Department of Housing and Urban Development assisted housing programs	2009 Picture of Subsidized Households, Department of Housing and Urban Development
ZIP code		
Economic deprivation[2]	Index of % residents employed in low-wage occupations (e.g. service, sales, construction, manufacturing, transportation), % households in poverty, % female-headed households with dependent children <18 years, % households on public assistance, % low-income households, % without high school diploma/GED, % unemployed	2007-2011 American Community Survey

[1] The US Census Bureau defines housing units to be a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied. Group quarters (e.g., treatment centers, correctional facilities, and homeless shelters) are not defined as housing units.49. American Community Survey and Puerto Rico Community Survey: 2011 Subject Definitions. Washington, DC: United States Census Bureau; 2011.

[2] The economic deprivation index was informed by: 50. Messer LC, Laraia BA, Kaufman JS, et al. The Development of a Standardized Neighborhood Deprivation Index. Journal of Urban Health : Bulletin of the New York Academy of Medicine 2006;83:1041-62, 51. Krieger N, Barbeau EM, Soobader MJ. Class matters: U.S. versus U.K. measures of occupational disparities in access to health services and health status in the 2000 U.S. National Health Interview Survey. International journal of health services : planning, administration, evaluation 2005;35:213-36. Principle components analysis (PCA) was conducted to confirm the dimensionality of the items across ZIP codes of all MSAs. Once confirmed through PCA, items were standardized by z-score, weighted by factor loadings, and summed to create the index.

Gentrification[3]	Index of percent change in the following indicators between 1990 and 2009: % poverty, % college or more among adults aged >= 25, % White, median household income, median monthly rent. Economic factors were adjusted for inflation using the Consumer Price Index.	Geolytics 1990 Long Form in 2010 Boundaries; 2007-2011 American Community Survey

Table 2. Distributions of ZIP code, county, and participant characteristics among 8,992 people who inject drugs living in 19 US metro areas in 2009

Characteristics	**Total** N (%) or Mean (Standard deviation)
	N= 8,992
Region[4]	
Northeast	2,122 (23.55)
South	3,605 (40.01)
Midwest	938 (10.41)
West	2,345 (26.03)
MSA (N=19)	
County (N=51)	
Percent unaffordable rental units among low-income households	85.18 (6.87)
Average number of months that applicants were on waiting lists for assisted housing	30.03 (17.65)
ZIP code (N=939)	
Economic deprivation	2.28 (2.23)
Gentrification	0.41 (1.45)
Participant characteristics	
Current age	45.76 (10.54)
Male	6,450 (71.73)
Race/ethnicity	

[3] The gentrification measure was informed by: 38. Freeman L, Braconi F. Gentrification and displacement - New York City in the 1990s. Journal of the American Planning Association 2004;70:39-52, 40. Marcuse P. Gentrification, Abandonment, and Displacement:Connections, Causes, and Policy Responses in New York City. Journal of Urban and Contemporary Law 1985;28:195–240, 52. Freeman L. There goes the 'hood : views of gentrification from the ground up. Philadelphia, PA: Temple University Press; 2006, 53. Huynh M, Maroko AR. Gentrification and Preterm Birth in New York City, 2008–2010. Journal of Urban Health : Bulletin of the New York Academy of Medicine 2014;91:211-20.. Principle components analysis (PCA) was conducted to confirm the dimensionality of the items across ZIP codes of all MSAs. Once confirmed through PCA, items were standardized by z-score, weighted by factor loadings, and summed to create the index.

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

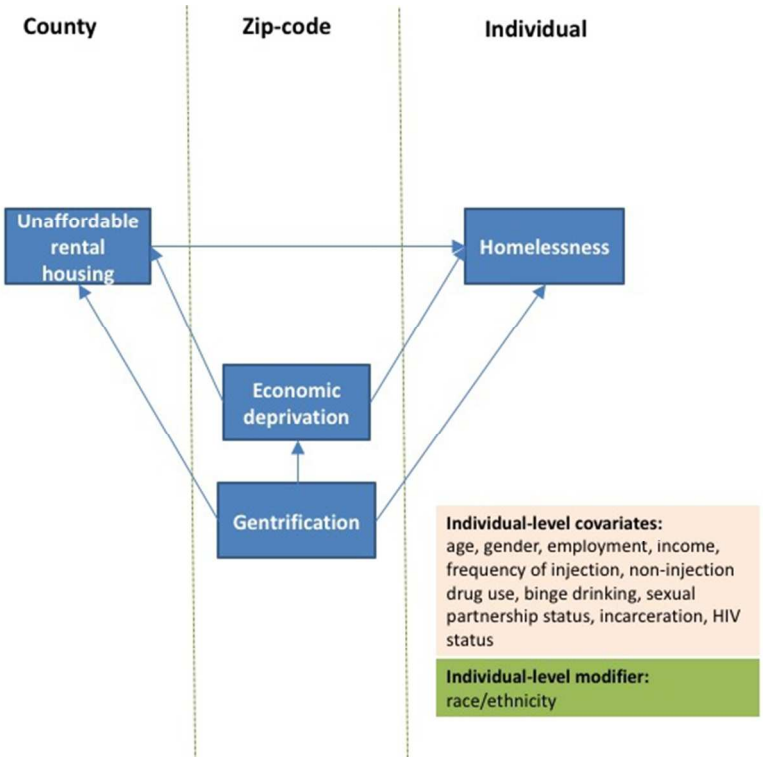
Latino	1,622 (18.04)
Black	4,662 (51.85)
White	2,708 (30.12)
Annual income (≤5000 USD)	5,488 (61.03)
Full-time employment	394 (4.38)
Incarceration	3,281 (36.50)
Homelessness	5,394 (59.99)
Daily injection	2,310 (25.69)
Binge drinking	4,939 (54.93)
Type of sexual partner in the past 12 months	
Main	4,454 (49.53)
Casual	4,370 (48.60)
Non-injection drug use	6,765 (75.23)
Recent HIV test result	
Negative result on most recent HIV test	6,986 (77.69)
Positive result on most recent HIV test	495 (5.50)

Table 3. Association of ZIP code, county, and participant characteristics with recent homelessness among people who inject drugs from 19 US metro areas in 2009

	Univariate model Odds ratio(95% Confidence interval)	Multivariable model Adjusted Odds ratio (95% Confidence interval) *
Intercept		19.58 (1.13, 339.80)
Region		
Northeast (Reference)	1.00	
South	1.19 (0.73, 1.93)	--
Midwest	0.71 (0.33, 1.55)	--
West	1.33 (0.77, 2.28)	--
MSA (N=19)		
Random intercept variance	0.06 (0, 2.61)	0.06 (0, 2.00)
County(N=51)		
Random intercept variance	0.26 (0.10, 0.70)	0.21 (0.07, 0.69)
Percent unaffordable rental units among low-income households	0.97 (0.94, 1.01)	0.99 (0.96, 1.02)
Average number of months that applicants were on waiting lists for assisted housing	1.00 (0.98, 1.01)	--
ZIP code (N=937)		
Random intercept variance	0.31 (0.23, 0.43)	0.17 (0.11, 0.26)
Economic deprivation	0.98 (0.95, 1.02)	
Gentrification	1.13 (1.07, 1.18)	1.11 (1.04, 1.17)
Participant Characteristics		
Current age	0.97 (0.96, 0.97)	0.98 (0.97, 0.98)
Sex (1=male)	0.88 (0.80, 0.98)	0.81 (0.73, 0.91)
Race/ethnicity		
White (reference)	1.00	1.00
Black	0.66 (0.58, 0.75)	0.76 (0.66, 0.87)
Latino	0.87 (0.75, 1.01)	0.83 (0.71, 0.97)
Annual income (5,000 USD	0.48 (0.44, 0.53)	0.48 (0.44, 0.53)

vs. more)		
Full-time employment	0.34 (0.27, 0.42)	0.38 (0.30, 0.49)
Incarceration	2.19 (1.98, 2.42)	1.84 (1.65, 2.05)
Daily injection (vs. less than daily)	0.81 (0.73, 0.91)	0.85 (0.76, 0.96)
Binge drinking	1.51 (1.38, 1.66)	1.30 (1.18, 1.44)
Non-injection drug use	1.41 (1.27, 1.57)	1.23 (1.10, 1.37)
Type of sexual partner in the past 12 months		
None	1.00	1.00
Main	1.15 (0.82, 1.60)	1.14 (0.81, 1.60)
Casual	2.10 (1.91, 2.31)	1.76 (1.60, 1.95)
Recent self-reported HIV test result		
Indeterminate result/or did not receive result (reference)	1.00	1.00
Negative result	0.78 (0.69, 0.88)	0.86 (0.76,0.99)
Positive result	0.49 (0.39, 0.62)	0.63 (0.50, 0.80)

* The multivariable model assessed the relationships of place-based factors significant at a p-value<0.20 in univariate models to homelessness, controlling for individual-level confounders.



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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Included in abstract on page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Page 3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Pages 4-5
Objectives	3	State specific objectives, including any prespecified hypotheses Page 5
Methods		
Study design	4	Present key elements of study design early in the paper Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants Page 5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pages 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Pages 5-6, 17-18 in Table 1
Bias	9	Describe any efforts to address potential sources of bias Page 9
Study size	10	Explain how the study size was arrived at Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pages 5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Page 6
		(*b*) Describe any methods used to examine subgroups and interactions Page 6
		(*c*) Explain how missing data were addressed Page 5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Page 7
		(*e*) Describe any sensitivity analyses N/A: None performed

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Page 5
		(b) Give reasons for non-participation at each stage Page 5
		(c) Consider use of a flow diagram Described in manuscript; no visual provided
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Page 7, 18-19
		(b) Indicate number of participants with missing data for each variable of interest Page 5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Page 7, 18-19
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Pages 6, 19-20
		(*b*) Report category boundaries when continuous variables were categorized Page 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A- no relative risk reported
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Pages 6, 8, and 10
Discussion		
Key results	18	Summarise key results with reference to study objectives Pages 7-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pages 7-10
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 9
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.