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Socioeconomic and racial/ethnic spatial polarization and incarceration among people who inject drugs in 19 US metropolitan areas, 2015☆

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A B S T R A C T

The purpose of this study is to test, for the first time, the association between spatial social polarization and incarceration among people who inject drugs (PWID) in 19 large U.S. metropolitan statistical areas (MSAs) in 2015. PWID were recruited from MSAs for the Centers for Disease Control and Prevention's 2015 National HIV Behavioral Surveillance. Administrative data were used to describe the ZIP-code areas, counties, and MSAs where PWID lived. We operationalized spatial polarization using the Index of Concentration at the Extremes (ICE), a measure that reflects polarization in race and household income at the ZIP-code level. We tested the association between spatial polarization and odds of past-year arrest and detainment using multilevel multivariable models. We found 37% of the sample reported being incarcerated in the past year. Report of past-year incarceration varied by race/ethnicity: 45% of non-Hispanic white PWID reported past-year incarceration, as did 25% of non-Hispanic Black PWID, and 43% of Hispanic/Latino PWID (N = 9047). Adjusted odds ratios suggest that Black PWID living in ZIP-code areas with a higher ICE score, meaning more white and affluent, had higher odds of past-year incarceration, compared to white PWID. In previous research, incarceration has been found to be associated with HIV acquisition and can deter PWID from engaging in harm reduction activities.

1. Introduction

Incarceration has been associated with HIV and racial/ethnic inequities in HIV diagnoses and other HIV-related outcomes among people who inject drugs (PWID) (Rhodes et al., 2005; Cooper, Friedman, et al., 2005; Cooper et al., 2007; Tempalski et al.). 2a The criminalization of drug use is a significant structural barrier to HIV prevention and treatment for PWID, and disproportionately affects non-white PWID (DeBeck et al., 2017; Rhodes et al., 2005). A review found that the intensity of policing predicts area-level vulnerability to HIV, Hepatitis C, and the opioid epidemic (Perlman & Jordan, 2018). Predominantly Black and low-income neighborhoods are particularly vulnerable to intense policing, leading to higher levels of incarceration in those areas (Kent & Carmichael, 2014). However, very few studies have examined placed-based correlates of arrest itself among PWID, specifically whether racial/ethnic and economic spatial polarization (Krieger, Waterman, et al., 2016) is related to the odds of being incarcerated.

In the U.S., racialized urban policing exists in tandem with racial and economic residential segregation (the physical separation of two or more groups into different geographic areas), allowing law enforcement agencies to heavily police predominately Black neighborhoods (Massey and Eggers, 1990, 1993; Reardon & Bischoff, 2011; Smith & Holmes,

☆ The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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2014). One study found that MSA-level place-based measures of urban disadvantage, which included residential segregation, were associated with increases in Black drug arrests over time in U.S. cities (Parker & Maggard, 2005). Low-income and predominately Black and Latino neighborhoods are sites for disproportionate police surveillance (Kent & Carmichael, 2014), and aggressive policing tactics (e.g., arrests for misdemeanors, sanctions for civil violations, and investigative stops of pedestrians and vehicles) commonly occur in poor, predominately non-white communities in urban areas (Parker & Maggard, 2005).

The Risk Environment Model is a useful theoretical framework for examining the social determinants, specifically the features of the social, economic, health service, law enforcement, and physical environments that occur at multiple levels (e.g., network, neighborhood, and city), that structure HIV vulnerability ability PWID.[2] A previous analysis using national surveillance data of 9170 PWID found that the risk environments for PWID differed by race and ethnicity (Cooper et al., 2016). Specifically, Black PWID were more likely than white PWID to live in ZIP code areas, which are theorized as proxy measures of local neighborhoods in the analysis, that were associated with HIV vulnerability, including socially and economically distressed areas, poor spatial access to substance use disorder treatment, and greater exposure to law enforcement activities (Cooper et al., 2016). Black PWID specifically lived in counties with higher mean drug-related arrest rates than white PWID; Latino PWID lived in MSA's with higher mean drug-related arrest rates than white and Black PWID. The same study also found that Black and Latino PWID were more likely to live in hyper-segregated neighborhoods, or highly segregated on multiple dimensions of neighborhood segregation, and concentrated poverty. This research allow us to conceptualize a pathway between neighborhood segregation, law enforcement features, and HIV transmission and progression among PWID, a socially vulnerable population that is at increased risk of HIV and can benefit from increased access to harm reduction services (Cooper et al., 2005a, 2007).

Increasing spatial and social polarization within US metropolitan areas suggests social equity measures should expand beyond conventional approaches of capturing residential segregation, i.e. the index of dissimilarity (Krieger et al., 2017). The index of Concentration at the Extreme measures spatial social polarization at multiple geographical levels by capturing extremes of deprivation and privilege. This measure differs from conventional measures of social inequality, such as the Index of Dissimilarity and the Gini coefficient, two measures of social inequality that do not capture spatial social polarization (Krieger, Waterman, et al., 2016). To illustrate, an area with 100% poverty and 100% high income, as measured by the ICE measure, would have the same Gini coefficient score - 0 for perfect equality.

An extant body of literature from recent years suggest that ICE is a valuable measure for the public health monitoring of social inequality extremes that produce health inequities (Feldman et al., 2015; Krieger et al., 2005, 2015, 2016a, 2016b, 2017). We build on the research mentioned earlier to examine the relationship between spatial social polarization, using the ICE measure that using household income and race/ethnicity at the ZIP code level, and the odds of past-year incarceration among PWID. We also assessed these associations by individual-level race/ethnicity to measure whether these measures may have associations with past-year incarceration that vary based on respondents' race and ethnicity.

2. Methods

2.1. Sample

This is a secondary analysis of existing data from the National HIV Behavioral Surveillance (NHBS), which collects data on HIV serostatus HIV-related behaviors and health service use among PWID, in addition to men who have sex with men and heterosexual individuals at higher risk for HIV infection, using respondent-driven sampling (Burt et al., 2010; Paz-Bailey et al., 2014). Data were drawn from the 2015 cycle of NHBS on PWID. To assess cross-sectional relationships between spatial polarization and past-year incarceration among PWID, we combined the 2015 NHBS data on PWID living in 19 US MSAs with data from the American Community Survey and other administrative sources (Paz-Bailey et al., 2014).

In 2015, 10,678 eligible adult ($\geq$ 18 years old) PWID were recruited as part of NHBS in 20 MSAs using respondent-driven sampling (RDS) techniques, in which recruited respondents could recruit up to 5 additional persons to take the survey by giving out coupons (Heckathorn, 2002; Rosenblum et al., 2014). We focused our analysis on the 19 NHBS MSAs in the conterminous United States; we omitted one NHBS site, San Juan, Puerto Rico, because of missing administrative data. Respondents were linked to ZIP codes and counties where they lived; homeless individuals were assigned to ZIP codes where they usually slept.

Across the 19 MSAs, 9941 PWID were eligible for the survey, consented to the survey, completed the survey, and provided valid responses. The sample was further reduced by removing data from PWID with missing ZIP codes. We additionally checked the validity of the reported ZIP codes. First, respondents in ZIP codes where multiple counties were reported were assigned to the county with the most NHBS respondents in order to ensure nesting of geographical areas. ZIP codes were then considered valid if the ZIP-County pairing for respondents had a corresponding ZCTA-County match in the 2010 Census relationship files. ZCTAs are Census approximations of ZIP codes. For the remainder of the paper, we use "ZIP code" to refer to both ZIP codes and ZCTAs. The process of excluding both missing and invalid ZIP codes (5.3%) resulted in a sample of 9410 PWID.

There are two primary reasons we adjust for PWID's county and MSA. First, we expect that persons within the same counties and MSAs are more similar, even after controlling for individual-level covariates, compared to persons in different countries or MSAs. So this adjustment accounts for the potential clustering of respondents within areas. Second, we are interested in assessing whether additional contextual information changed the results.

Following previous analyses, respondents who were bi-racial non-Hispanic were assigned to the Black non-Hispanic group if one of the reported races was Black; otherwise they are assigned to white non-Hispanic if one of their reported races was white (Rosenblum et al., 2014). We then excluded participants identifying as transgender, and participants who did not identify as either white non-Hispanic, Black non-Hispanic, or Hispanic, due to small sample sizes, resulting in a sample of 9161 PWID (2.5%). Respondents with missing values for past-year incarceration, individual covariates, or place characteristics were also removed (1.1%); the final analysis sample included 9047 PWID in 1047 ZIP codes, 73 counties, and 19 MSAs. The Emory University Institutional Review Board (IRB) approved study protocols.

2.2. Outcome: past-year incarceration

Respondents were asked "Have you ever been held in a detention center, jail, or prison for more than 24 h?" Respondents who answered "Yes" were then asked "During the past 12 months […] have you been held in a detention center, jail, or prison, for more than 24 h?" We focused our analyses on the outcome of past-year incarceration (1 = incarcerated in the past 12 months, 0 = not incarcerated in the past 12 months).

2.3. Exposure: ICE

Douglas Massey (2001) first proposed the Index of Concentration at the Extreme (ICE) measure (Massey, 2001), using the following formula

[2] The American Community Survey Household Income tables are not provided for non-Hispanic Black households.

(Krieger et al., 2015):

$$ICE_i = (A_i - P_i) / T_i$$

Where i represents the geographic area of interest (in this case, ZIP code), A_i denotes the number of affluent (e.g. high-income households) in area i, P_i denotes the number of poor (e.g. low-income households) in area i, and T_i denotes the total number in area i (e.g. total households). (Feldman et al., 2015; Krieger, Waterman, et al., 2016) The ICE measure has a possible range from −1 to +1. We followed recent work by Drs. Krieger (Krieger et al., 2005, 2015, 2016a) and Feldman (Feldman et al., 2015) that uses ICE measures based on distributions of household income and race/ethnicity. Incorporating race and ethnicity into the ICE measure recognizes the association between race, ethnicity, socioeconomic status, and geography in the form of neighborhood effects. (Krieger et al., 2005) The ICE measure has been found to be a reliable metric of racialized economic segregation in studies examining population health and health inequities, including infant mortality, (Krieger, Waterman, et al., 2016) premature mortality, hypertension, (Feldman et al., 2015) breast cancer, (Krieger, Singh, & Waterman, 2016) assaults, (Krieger et al., 2017) and Black carbon exposure. (Krieger et al., 2015) We used two ICE measures: (1) high-income non-Hispanic white households vs. low-income Black households; (Rhodes et al., 2005) (2) high-income non-Hispanic white households vs. low-income Hispanic households. Large values on these ICE measures (closer to +1) indicate that an area is more heavily concentrated with high-income white non-Hispanic households with proportionally fewer low-income Black or Hispanic households. Small values (closer to −1) indicate that households within a ZIP code are predominantly low-income Black or Hispanic households, respectively. Values close to 0 could mean different things: there are neither many high-income white households nor many low-income Black or Hispanic households; alternatively, the proportion of high-income white and low-income Black or Hispanic households may balance out. Except in the context of the ICE scores, the term *Black* denotes people who identify as non-Hispanic Black.

We used $125,000 and $25,000 for the high and low household income thresholds based on proximity to published estimates on the 20th and 80th percentiles of household income in the 2013–2017 ACS. Details on variable sources and construction are provided in Table 1. In sensitivity analyses, we also considered an alternative exposure where the MSA-level geographic area ICE score is subtracted from the ZIP-level ICE score. This ZIP-MSA ICE score represents the ZIP code area's ICE score relative to its MSA.

2.4. Place-based covariates

We controlled for county-level odds ratios for housing discrimination for non-Hispanic Black vs. non-Hispanic white and Hispanic vs. non-Hispanic white because housing discrimination and racial/ethnic residential polarization and segregation are linked. Additionally, large geographic areas may have different underlying racial/ethnic distributions and income distributions. Thus, we also included MSA-level poverty rates and percentage of residents who are non-white as controls. See Table 1 for details on measures and their sources.

2.5. Individual-level covariates

We considered the following individual-level covariates: age, race/ethnicity, sex, marital status, high school graduation status, income grouping, full-time employment status, self-reported HIV status, homelessness within the past 12 months, daily injection frequency, binge drinking in the past 30 days, and non-injection drug use.

2.6. Statistical analysis

We first describe the distributions of the primary ICE exposures and other covariates by past-year incarceration status in Table 2. We constructed box plots for the two ICE measures across the sample (Fig. 1). We then assessed bivariate relationships by fitting separate logistic regression models for each covariate and calculating odds ratios with 95% confidence intervals. For continuous independent variables, odds ratios are always presented in terms of a 1 standard deviation (SD) increase in that variable for greater interpretability.

For each of the two ICE measures, we then fitted 3 multivariable models: 1. Primary model; 2. Primary model with interaction; 3. Extended model. The purpose of the primary model is to estimate the association between ICE and past-year incarceration while adjusting for place-based covariates and the initial set of individual-level covariates. By including individual covariates, our analytical goal is to control for potential confounders. We include interaction effect to measure whether these measures may have associations with past-year incarceration that vary based on respondents' race and ethnicity (primary model with interactions). We cannot determine the time-ordering of events because

Table 1
Place-based exposures and measures studied and data sources used to operationalize constructs.

Measures	Source and Construction
ZIP	
ICE: Concentration of high-income non-Hispanic white households vs. low-income Black alone[c] households	American Community Survey (ACS (Rhodes et al., 2005)) Tables B19001, B19001H, B19001B: Calculated as: $\frac{(WhiteHH > \$125K - BlackHH < \$25K)}{HH}$ where HH is households and white HH is short for white non-Hispanic households, and Black HH is short for Black alone households for Census ZCTAs. Thresholds for ICE measures are based proximity to the 20th and 80th percentiles for household income from ACS Table B19080.
ICE: Concentration of high-income non-Hispanic white households vs. low-income Hispanic/Latinx households	ACS[b] Tables B19001, B19001H, B19001I: Calculated as: $\frac{(WhiteHH > \$125K - HispanicHH < \$25K)}{HH}$ where HH is households, white HH is short for non-Hispanic white households, and Hispanic HH is short for Hispanic or Latinx households for Census ZCTAs.
County	
Housing Discrimination for non-Hispanic Black individuals	Source and calculation: Home Mortgage Disclosure Act (HMDA) loan-level data from FFIEC, using methods proposed in Mendez et al., 2011. (Mendoza et al., 2015) These odds ratios are estimated from mixed effect logistic regression models controlling for applicant sex, income, loan amount, and race/ethnicity. Race/ethnicity associations are allowed to vary by county (random slope). Measure: Odds ratio of being denied from loan applications for non-Hispanic Blacks compared to non-Hispanic whites.
Housing Discrimination for Hispanic/Latinx individuals	Source and calculation: HMDA loan-level data from FFIEC. See above. Measure: Odds ratio of being denied from loan applications for Latinos compared to non-Hispanic whites
MSA[d]	
Household Poverty rate	ACS (Rhodes et al., 2005) Table B17017 Percentage of households with income in the past 12 months below the poverty level
Percent non-white[a] residents	ACS[b] Table B03002 Defined as: 100 – (Percentage of residents identifying as non-Hispanic white alone)

[a] Non-white includes participants who report identifying as Latino or Hispanic.
[b] All ACS measures are based on 2013–2017 5-year estimates.
[c] Black Alone refers to people who reported Black or African-American and did not report any other race.
[d] Metropolitcan Statistical Area (MSA)-level measures are constructed from the NHBS 2015 list of counties for each RDS site.

Table 2
Distribution of participant characteristics among a sample of people who inject drugs (PWID) living in 19 US metropolitan statistical areas (MSA) in 2015, total and by past-year incarceration, National HIV Behavioral Surveillance (NHBS).

Variable	Overall Sample (N = 9047)	Incarcerated past-year (N = 3353)	Not incarcerated past-year (N = 5694)
	Mean (SD) or N (%)		
ZIP			
ICE: Concentration of high-income white households vs. low-income Black households	−0.07 (0.22)	−0.03 (0.21)	−0.09 (0.23)
ICE: Concentration of high-income white households vs. low-income Hispanic/Latinx households	0.02 (0.16)	0.03 (0.16)	0.02 (0.15)
Place-based Covariates			
County Housing Discrimination: non-Hispanic Black[a]	2.24 (0.52)	2.19 (0.50)	2.27 (0.52)
County Housing Discrimination: Hispanic/Latino[a]	1.36 (0.27)	1.35 (0.27)	1.36 (0.26)
MSA HH Poverty rate	12.8 (3.33)	12.9 (3.35)	12.7 (3.31)
MSA Percentage non-white residents	50.6 (13.6)	50.6 (14.7)	50.6 (13.0)
Individual Covariates			
Age	43.8 (12.5)	39.3 (11.3)	46.5 (12.4)
Gender			
Male	6465 (71.5%)	2608 (77.8%)	3857 (67.7%)
Female	2582 (28.5%)	745 (22.2%)	1837 (32.3%)
Race/Ethnicity			
White non-Hispanic	3923 (43.4%)	1764 (52.6%)	2159 (37.9%)
Black non-Hispanic	3465 (38.3%)	868 (25.9%)	2597 (45.6%)
Hispanic/Latino	1659 (18.3%)	721 (21.5%)	938 (16.5%)
High school graduate	6343 (70.1%)	2382 (71.0%)	3961 (69.6%)
Married	1209 (13.4%)	387 (11.5%)	822 (14.4%)
Household Income category			
$0 to $5000	2950 (32.6%)	1307 (39.0%)	1643 (28.9%)
$5000 - $9999	2088 (23.1%)	617 (18.4%)	1471 (25.8%)
$10,000 - $14,999	1678 (18.6%)	554 (16.5%)	1124 (19.7%)
≥ $15,000	2331 (25.8%)	875 (26.1%)	1456 (25.6%)
Employed full-time	465 (5.1%)	154 (4.6%)	311 (5.5%)
Self-reported HIV positive	474 (5.2%)	129 (3.9%)	345 (6.1%)
Homeless, past 12 mo.	5628 (62.2%)	2594 (77.4%)	3034 (53.3%)
Daily injection, past 12 mo.	7628 (84.3%)	2938 (87.6%)	4690 (82.4%)
Binge drinking, past 30 days	2553 (28.2%)	1015 (30.3%)	1538 (27.0%)
Non-injection drug use, past 12 mo.	6961 (76.9%)	2723 (81.2%)	4238 (74.4%)
Recruiter past-year incarceration			
No	5391 (59.6%)	1666 (49.7%)	3725 (65.4%)
Yes	3339 (36.9%)	1549 (46.2%)	1790 (31.4%)
Missing/Seed	317 (3.5%)	138 (4.1%)	179 (3.1%)

[a] Odds ratio of being denied from loan applications for each respective racial/ethnic group, compared to non-Hispanic white.

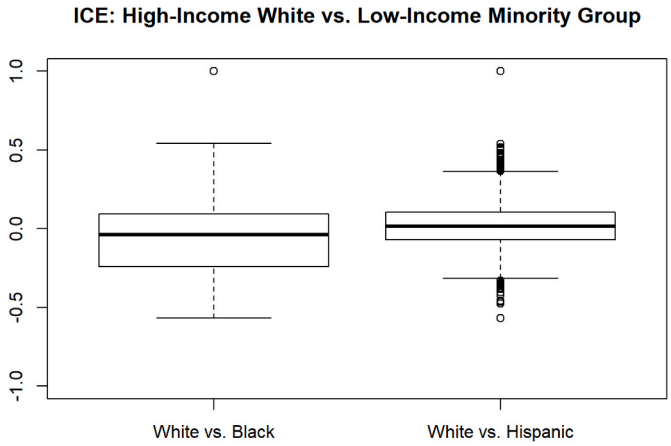

Fig. 1. Boxplot of distribution for two Index of Concentration at the Extremes (ICE) measures: high-income white households vs. low-income Black households and high-income white households vs. low-income Hispanic/Latino households, American Community Survey (2013–2017) data for ZIP code areas where a sample of people who inject drugs (PWID) live (N = 9047) in 19 U.S. Metropolitan statistical Areas in 2015, National HIV Behavioral Surveillance (NHBS).

the data are cross-sectional, but recognize that some additional individual covariates may mediate the relationship between ICE and past-year incarceration or be the result of the past-year incarceration event (or non-event) itself. For example, past-year incarceration may have then made respondents much less likely to have full-time employment or a permanent residence in the past year – in this case, controlling for full-time employment or homelessness may not be appropriate for understanding the association between ICE and past-year incarceration. The initial set of individual-level covariates included in this primary model *excludes* such individual covariates.

For the second model, or the primary model with interaction, we introduce interactions between the ICE measures and participant race/ethnicity to assess race/ethnicity-specific associations. We presented the exponentiated interaction terms, which can be interpreted as the ratio of odds ratios for a 1 SD increase in the Black-white and Hispanic/white ICE measures, as well as the white-, Black- and Hispanic-specific odds ratios for the ICE measure. In order to assess the robustness of our results to the set of individual covariates, we included a third model, called the extended model, which controlled for a second set of individual covariates, which may act as confounders for the previously discussed reasons. Throughout, we emphasize effect sizes and estimated confidence intervals for the ICE measures' association with past-year incarceration in different race/ethnicity groups.

All bivariate and multivariable logistic regression models include random intercept terms at the ZIP code, county, and MSA-level to adjust for potential geographical clustering and the RDS study site. Additionally, all multivariable models control for the respondent's recruiter's past-year incarceration status. The inclusion of the recruiter-level outcome was meant to adjust for lingering RDS bias as a result of the sampling design that may not have been captured by the geographic random intercepts and the other covariates (Mendoza et al., 2015). In sensitivity analyses presented in the supplemental materials, we assessed how the estimated odds ratio for the ICE measurement varies across different model specifications excluding or including the recruiter-level outcome, and under alternative random intercept specifications.

3. Results

3.1. Sample description

This sample of 9047 PWID lived in 19 MSAs, 73 counties, and 1047 ZIP code areas. Seventy-one percent were men and 29% were women (Table 2). Self-reported past-year incarceration varied by race/ethnicity: 45% of non-Hispanic white PWID reported past-year incarceration, as did 25% of non-Hispanic Black PWID, and 43% of Hispanic/Latino PWID. Nearly forty-four percent of the sample was non-Hispanic white,

Table 3A
Multilevel bivariate and multivariable associations of Index of Concentration at the Extremes (ICE) for **high-income white households vs. low-income Black households** with reported past-year incarceration, where a sample of people who inject drugs (PWID) live (N = 9047) in 19 U.S. metropolitan statistical areas (MSA) in 2015[a], National HIV Behavioral Surveillance (NHBS).

Variable	Bivariate Models	Multivariable Model 1a: Primary model	Multivariable Model 1 b: Primary model with interaction	Multivariable Model 1c: Extended model
	Odds ratio (95% CI)			
ZIP				
ICE: Concentration of high-income white households vs. low-income Black households (1 SD = 0.22)	1.20 (1.12, 1.29)	1.02 (0.95, 1.09)	0.95 (0.87, 1.05) 1.15 (1.02, 1.30)	0.98 (0.89, 1.07) 1.11 (0.98, 1.25)
Race/ethnicity × ICE			1.04 (0.89, 1.21)	1.04 (0.89, 1.22)
- Black × ICE			–	–
- Hispanic × ICE			1.10 (1.00, 1.21)	1.08 (0.98, 1.19)
- White (reference)			0.99 (0.86, 1.14)	1.02 (0.88, 1.17)
Individual race/ethnicity				
- Black				
- Hispanic/Latino				
Place-based Covariates				
County Housing Discrimination: non-Hispanic Black (1 SD = 0.52)	0.85 (0.73, 1.00)	0.87 (0.72, 1.04)	0.87 (0.72, 1.04)	0.87 (0.73, 1.03)
County Housing Discrimination: Hispanic/Latino (1 SD = 0.27)	0.92 (0.77, 1.10)	1.16 (0.96, 1.39)	1.15 (0.96, 1.39)	1.13 (0.94, 1.35)
MSA HH Poverty rate (1 SD = 3.33)	1.09 (0.89, 1.32)	1.03 (0.90, 1.18)	1.03 (0.90, 1.17)	1.02 (0.89, 1.17)
MSA Percentage non-white residents (1 SD = 13.6)	1.02 (0.83, 1.25)	1.04 (0.89, 1.21)	1.03 (0.89, 1.20)	1.02 (0.88, 1.19)
Individual Covariates				
Age (1 SD = 12.51)	0.57 (0.54, 0.60)	0.59 (0.55, 0.62)	0.59 (0.55, 0.62)	0.63 (0.59, 0.67)
Female (male: ref)	0.63 (0.57, 0.70)	0.55 (0.49, 0.61)	0.55 (0.49, 0.61)	0.56 (0.50, 0.63)
Race/eth. (White: ref)				
Black	0.50 (0.45, 0.57)	0.81 (0.70, 0.92)	0.85 (0.74, 0.98)	0.88 (0.76, 1.02)
Hispanic/Latino	0.95 (0.84, 1.08)	1.02 (0.89, 1.16)	1.01 (0.88, 1.15)	1.02 (0.89, 1.17)
High school graduate	1.01 (0.92, 1.12)	0.92 (0.83, 1.02)	0.92 (0.83, 1.02)	0.98 (0.88, 1.09)
Married	0.81 (0.71, 0.93)	0.88 (0.76, 1.01)	0.88 (0.76, 1.01)	0.97 (0.84, 1.12)
Household Income (<$5 K: reference)				
$5000 - $9999	0.56 (0.49, 0.63)			0.72 (0.63, 0.82)
$10,000 - $14,999	0.61 (0.54, 0.70)			0.78 (0.68, 0.89)
≥ $15,000	0.71 (0.64, 0.80)			0.81 (0.72, 0.92)
Employed full-time	0.76 (0.62, 0.93)			0.69 (0.56, 0.86)
Self-reported HIV positive	0.63 (0.51, 0.78)			0.81[+] (0.64, 1.01)
Homeless, past 12 mo.	2.58 (2.33, 2.86)			1.95 (1.75, 2.17)
Daily injection, past 12 mo.	1.73 (1.52, 1.97)			1.49 (1.30, 1.71)
Binge drinking, past 30 days	1.12 (1.01, 1.24)			1.05 (0.95, 1.17)
Non-injection drug use, past 12 mo.	1.24 (1.10, 1.38)			1.08 (0.96, 1.21)
Recruiter past-year incarceration (No: ref)				
Yes	1.59 (1.44, 1.74)	1.40 (1.27, 1.54)	1.40 (1.27, 1.54)	1.35 (1.22, 1.49)
Missing/Seed	1.58 (1.24, 2.01)	0.97 (0.76, 1.25)	0.97 (0.76, 1.25)	1.02 (0.79, 1.31)
Random Effects	**Variance Estimate (SE)**			
MSA		<0.01	<0.01	0.015 (0.026)
County		0.063 (0.026)	0.062 (0.025)	0.041 (0.030)
ZIP		0.038 (0.021)	0.035 (0.020)	0.020 (0.018)

[a] When independent variables are continuous, the odds ratio (OR) is calculated for a 1 standard deviation difference in that variable.

38% was non-Hispanic Black, and 18% were Latino/Hispanic. Approximately 56% reported an annual household income <$10,000 and 62% reported being homeless in the past year.

PWID resided in ZIP code areas where both ICE values ranged from a minimum of −0.57 to a maximum of 1 (not presented in tables). The median value for ICE (high-income white vs. low-income Black) was −0.07; the 25th percentile was −0.24 and the 75th percentile was 0.09. The median value for ICE (the high-income white vs. low-income Hispanic/Latino) was 0.02; the 25th percentile was −0.07 and the 75th percentile was 0.11. Median values close to zero suggest that the median

Table 3B
Multilevel bivariate and multivariable associations of Index of Concentration at the Extremes (ICE) for **high-income white households vs. low-income Hispanic/Latino households** with reported past-year incarceration, where a sample of people who inject drugs (PWID) live (N = 9047) in 19 U.S. metropolitan statistical areas in 2015[a], National HIV Behavioral Surveillance (NHBS).

Variable	Bivariate Models	Multivariable Model 2a: Primary model	Multivariable Model 2 b: Primary model with interaction	Multivariable Model 2c: Extended model
	Odds ratio (95% CI)			
ZIP				
ICE: Concentration of high-income white households vs. low-income Hispanic/Latino households (1 SD = 0.16)	1.07 (1.00, 1.14)	1.00 (0.94, 1.07)	0.95 (0.88, 1.02)	0.96 (0.88, 1.03)
Race/ethnicity × ICE			1.13 (0.99, 1.28)	1.11 (0.97, 1.25)
- Black × ICE			1.11 (0.99, 1.25)	1.13 (1.01, 1.27)
- Hispanic × ICE			–	–
- White (reference)			1.07 (0.95, 1.19)	1.06 (0.94, 1.18)
Individual race/ethnicity			1.05 (0.96, 1.16)	1.08 (0.98, 1.19)
- Black				
- Hispanic/Latino				
Place-based Covariates				
County Housing Discrimination: non-Hispanic Black (1 SD = 0.52)	0.85 (0.73, 1.00)	0.86 (0.72, 1.04)	0.85 (0.71, 1.02)	0.85 (0.72, 1.01)
County Housing Discrimination: Hispanic/Latino (1 SD = 0.27)	0.92 (0.77, 1.10)	1.16 (0.96, 1.40)	1.16 (0.96, 1.39)	1.13 (0.94, 1.35)
MSA Household Poverty rate (1 SD = 3.33)	1.09 (0.89, 1.32)	1.03 (0.90, 1.18)	1.03 (0.90, 1.18)	1.02 (0.89, 1.18)
MSA Percentage non-white residents (1 SD = 13.6)	1.02 (0.83, 1.25)	1.04 (0.89, 1.21)	1.03 (0.88, 1.20)	1.02 (0.88, 1.19)
Individual Covariates				
Age (1 SD = 12.51)	0.57 (0.54, 0.60)	0.59 (0.55, 0.62)	0.59 (0.55, 0.62)	0.63 (0.59, 0.66)
Female (male: ref)	0.63 (0.57, 0.70)	0.55 (0.49, 0.61)	0.55 (0.49, 0.61)	0.56 (0.50, 0.62)
Race/eth. (White: ref)				
Black	0.50 (0.45, 0.57)	0.80 (0.70, 0.91)	0.78 (0.68, 0.89)	0.82 (0.72, 0.94)
Latino	0.95 (0.84, 1.08)	1.01 (0.89, 1.16)	1.01 (0.88, 1.15)	1.02 (0.89, 1.17)
High school graduate	1.01 (0.92, 1.12)	0.92 (0.83, 1.02)	0.92 (0.83, 1.02)	0.98 (0.88, 1.09)
Married	0.81 (0.71, 0.93)	0.88 (0.76, 1.01)	0.88 (0.76, 1.01)	0.97 (0.84, 1.12)
Household Income (<$5 K: reference)				
$5000 - $9999	0.56 (0.49, 0.63)			0.72 (0.63, 0.82)
$10,000 - $14,999	0.61 (0.54, 0.70)			0.78 (0.68, 0.90)
≥ $15,000	0.71 (0.64, 0.80)			0.81 (0.71, 0.92)
Employed full-time	0.76 (0.62, 0.93)			0.69 (0.56, 0.86)
Self-reported HIV positive	0.63 (0.51, 0.78)			0.81 (0.65, 1.01)
Homeless, past 12 mo.	2.58 (2.33, 2.86)			1.96 (1.75, 2.18)
Daily injection, past 12 mo.	1.73 (1.52, 1.97)			1.48 (1.29, 1.70)
Binge drinking, past 30 days	1.12 (1.01, 1.24)			1.05 (0.95, 1.17)
Non-injection drug use, past 12 mo.	1.24 (1.10, 1.38)			1.08 (0.96, 1.21)
Recruiter past-year incarceration (ref: No)				
Yes	1.59 (1.44, 1.74)	1.40 (1.27, 1.54)	1.40 (1.27, 1.55)	1.35 (1.23, 1.50)
Missing/Seed	1.58 (1.24, 2.01)	0.97 (0.76, 1.25)	0.98 (0.76, 1.25)	1.02 (0.80, 1.32)
Random Effects	**Estimate (SE)**			
MSA		<0.01	<0.01	0.018 (0.027)
County		0.065 (0.026)	0.063 (0.025)	0.038 (0.031)
ZIP		0.036 (0.021)	0.033 (0.020)	0.017 (0.018)

[a] When independent variables are continuous, the odds ratio (OR) is calculated for a 1 standard deviation difference in that variable.

participant resided in an area that was neither very deprived nor very privileged based on race/ethnicity and income, or the proportions of high-income white and low-income minority households balanced out.

3.2. Bivariate results

The bivariate models indicated a significant association between both ICE measures for ZIP code areas and past-year incarceration for all PWID. We found that PWID had a 20% higher odds of being incarcerated in the past year, when living in ZIP code areas that scored one standard deviation *higher* on the ICE measure comparing high-income white vs. low-income Black households, after accounting for ZIP, county, and MSA clustering (OR: 1.20; 95% CI: 1.12, 1.29; Table 3A). We found that PWID living in ZIP code areas that scored one standard deviation *higher* on the ICE measure comparing high-income non-Hispanic white vs. low-income Hispanic households had a 7% higher odds of reporting past-year incarceration (OR: 1.07; 95% CI: 1.00, 1.14; Table 3B).

3.3. Multivariable results

The primary model controlling for individual- and place-level covariates (Table 3A, Model 1a) shows no overall association between ZIP-level ICE (high-income white vs. low-income Black) and the odds of past-year incarceration (aOR: 1.02; 95% CI: 0.95, 1.09). However, including the primary model with interaction (Model 1 b) suggests that the association between ZIP-level ICE (high-income white vs. low-income Black) and the log odds of past-year incarceration varied by individual PWID race/ethnicity. Specifically, the change in odds for past-year incarceration for a 1 SD increase in the ICE measure was 15% higher among Black PWID as compared to white PWID (Exponentiated interaction term: 1.15; 95% CI: 1.02, 1.30; Table 3A, Model 1 b). The estimated effect size among Black PWID suggests an association in which a 1 SD increase in the ICE measure was associated with a 10% increase in the odds of past-year incarceration (Black aOR: 1.10; 95% CI: 1.00, 1.21; p-value = 0.051).

In the extended model that controlled for additional individual covariates that may be in the causal pathway, be confounders, or occur after past-year incarceration, the estimated associations were broadly consistent (Table 3a, Model 1c). Fig. 2a plots the race/ethnicity-specific odds ratios for the primary model with interaction and extended model.

In multivariable models using the ICE measure comparing high-income white vs. low-income Hispanic households, we found that the change in odds for past-year incarceration for a 1 SD increase in the ICE measure was 13% higher among Hispanic PWID than among white PWID in the model that controlled for additional individual covariates (exponentiated interaction term: 1.13; 95% CI: 1.01, 1.27; Table 3B, Model 2c). Fig. 2B shows associations for these two multivariable models for white, Black, and Hispanic PWID.

The supplemental tables and figures have results from analyses on ZIP-level ICE scores that adjusted for MSA-level ICE score. We found that point estimates and substantive conclusions did not change (Supplemental Tables S1a and S1b).

4. Discussion

This analysis is the first to show an association between spatial concentration of privilege and past-year incarceration among a sample of PWID. Approximately 37% of the sample reported incarceration in the past year. We found that the increase in the odds of past-year incarceration associated with a higher ZIP code-level ICE score (high-income white versus low-income Black households) was higher among Black PWID than white PWID. Specifically, we found that the increase in the odds of past-year incarceration associated with a higher ZIP code-level ICE score (high-income white versus low-income Black households) was higher among Black PWID compared to white PWID; the 95% confidence interval suggests that close to no difference as well as more pronounced differences are also compatible with the data. The ICE index comparing high-income white non-Hispanic households to low-income Hispanic households suggests a difference in the relationship between ICE and past-year incarceration among Hispanics and Black respondents compared to non-Hispanic white respondents. The estimates did not indicate a difference among Hispanics and white non-Hispanics when using the other ICE index comparing high-income white and low-income Black households. Second, the race/ethnicity-specific estimated odds ratios for an increase in the ICE were only moderate for Black and Hispanic PWID. The substantial incarceration rate in this low-income, low-education sample is consistent with data showing that socially and economically disadvantaged groups are more likely to be under correctional supervision (Western & Pettit, 2010).

Literature on racial profiling by law enforcement may help to explain

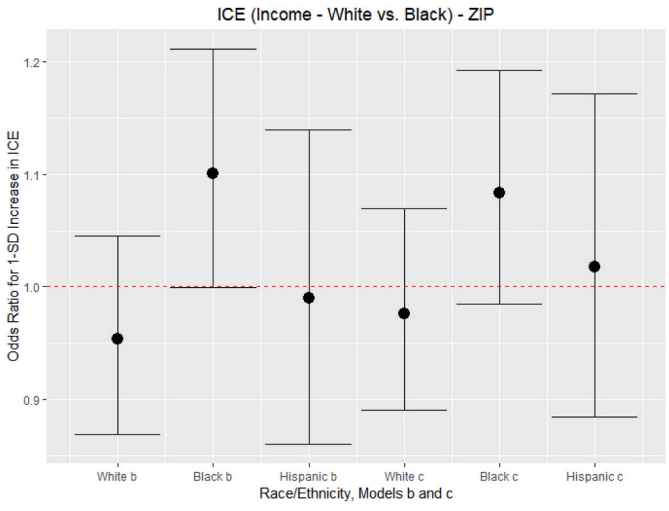

Fig. 2A. Boxplot of multivariate associations of Index of Concentration at the Extremes (ICE) for **high-income white households vs. low-income Black households** with reported past-year incarceration, where a sample of people who inject drugs (PWID) live (N = 9047) in 19 U.S. metropolitan statistical areas in 2015[a], National HIV Behavioral Surveillance (NHBS)

[a] When independent variables are continuous, the odds ratio (OR) is calculated for a 1 standard deviation difference in that variable.

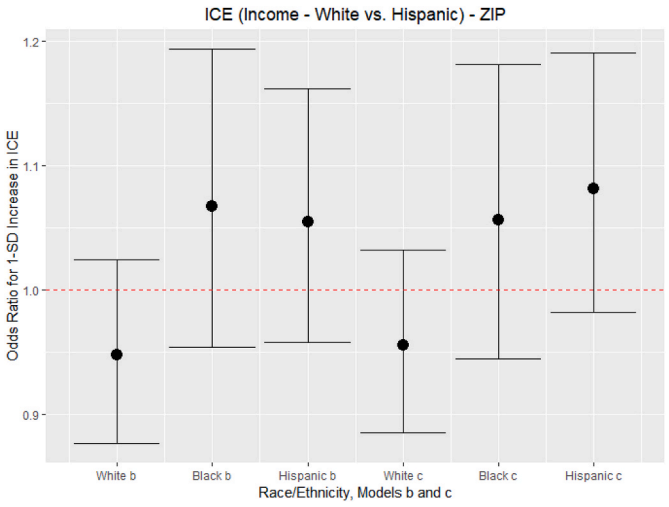

Fig. 2B. Boxplot of multivariate associations of Index of Concentration at the Extremes (ICE) for **high-income white households vs. low-income Hispanic/Latino households** with reported past-year incarceration, where a sample of people who inject drugs (PWID) live (N = 9047) in 19 U.S. metropolitan statistical areas in 2015[a], National HIV Behavioral Surveillance (NHBS).

why Black PWID are more vulnerable to arrest in areas with higher concentrations of social and economic privilege measured by racial composition and socioeconomic status. Black PWID who live in urban ZIP code areas with higher concentrations of high-income white households (as opposed to predominantly low-income Black neighborhoods) may be more likely to be racially profiled by law enforcement agents, leading to higher rates of detainment (Welch, 2007). Racial profiling is the discriminatory practice by law enforcement officials to use a person's perceived race and ethnicity as grounds to suspect they have committed an offense (Racial Profiling, 2019). The War on Drugs reinforced negative stereotypes regarding Black people, substance use, and criminality, leading to increased suspicion and targeting. Black PWID may be more likely to draw the suspicion of police officers on the basis of their race, the perception that they do not belong in such areas, and the stereotype of being criminal. Police surveillance and crackdowns of Black PWID in public spaces heightens the risk for these PWID to exist in outside spaces, and compromises harm reduction practices for PWID (Cooper, Moore, et al., 2005).

The study finds that Black PWID who lived in whiter, more affluent areas had higher odds of past-year incarceration, despite greater police surveillance in low-income, predominantly Black communities in the United States. Evidence suggests that the likelihood of law enforcement to stop and arrest Black individuals is sensitive to the racial composition of the local environment, in which Black individuals are more to be stopped and searched in predominantly white neighborhoods (Gaston, 2019a, 2019b; Meehan & Ponder, 2002; Renauer, 2012). Residents of more white and more affluent neighborhoods in urban areas may also demand greater police presence to address non-criminal "nuisance" behaviors associated with poverty, substance use disorders, and mental illness (Bass, 2001). A study of drug arrests from 2009 to 2013 in St. Louis found that drug law enforcement officers tended to target people suspects whose race was incongruent with the neighborhood racial composition (Gaston, 2019a). Another study of drug arrests within 56 police service areas in Washington, D.C. found evidence for the increase in Black arrests with higher percentage of white residents in an area (Fielding-Miller et al., 2016). This maintains inequitable patterns of policing PWID in which impoverished Black PWID experience heightened risk of targeting and arrest in wealthier and more white neighborhoods, which could lead to higher rates of incarceration. Given that such neighborhoods tend to have more resources that may be of benefit to PWID than predominantly Black neighborhoods (Cooper et al., 2005b, 2009, 2012), these findings highlight concerns over non-white PWID's ability to navigate such areas.

5. Limitations

There are numerous limitations associated with this study that are worth noting. First, because our study was cross-sectional in nature, we could only relate the ICE score for the participant's *current* ZIP code with past-year incarceration, which may be different from the ICE score at the time of incarceration. Research shows that parolees have high rates of residential mobility and low rates of returning to their pre-prison neighborhood (Harding et al., 2013), but are more likely to return to disadvantaged neighborhoods nonetheless (Lee et al., 2017). Second, we base the ICE scores on data for Census ZCTAs, which are approximations of ZIP codes. Furthermore, we were limited to using ZIP code areas as crude but useful proxy representations of neighborhoods as conceptualized. Third, the ICE scores are based on household data from the ACS and will exclude persons not residing in housing units. Fourth, there were fewer Hispanic PWID in the analytical sample (18.3%) then Black and white PWID, so the statistical power for detecting significant differences among Hispanic respondents may have been more limited. We also note that the ICE measure cannot differentiate between areas with close-to-zero ICE scores due to a roughly equal number of high-income White and low-income Black incomes and close-to-zero ICE scores due to the vast majority of households having incomes closer to the median.

Many measured behaviors from NHBS may not reflect behaviors prior to past-year incarceration for those individuals with a history of incarceration, and in fact, incarceration may have influenced these behaviors. We showed results across different model specifications to alleviate these concerns, but ultimately, we do not have a time-ordering of behaviors and past-year incarceration to address this issue fully. Further research is needed to understand these relationships better. Finally, the results reported here may not generalize to PWID outside the analytical sample considered here. We note this because the NHBS targets MSAs with high HIV prevalence (National HIV Behavioral Surveillance, 2022), and the RDS approach may result in geographically clustered participants within the sampled areas (Rudolph et al., 2014). A different sample of PWID in a different sample of ZIP code areas could result in a different relationship between past-year incarceration and ZIP-level ICE.

6. Conclusions

We found substantial rates of past-year incarceration among PWID regardless of race/ethnicity. Specifically, the increase in odds for past-year incarceration associated with living in local urban areas with higher concentrations of high-income white households (as compared to low-income Black households) was higher for Black PWID than for white PWID. Incarceration is associated with HIV acquisition and can deter PWID from engaging in harm reduction activities. Black PWID living in more privileged areas, compared to predominantly Black and low-income ones, may be subjected to higher odds of arrest and subsequent incarceration, which can deter PWID from engaging in harm reduction activities and HIV prevention. These findings suggest the utility of using spatial polarization measures and the usefulness of examining areas with concentrated privilege as sites for harm reduction through targeting law enforcement. Given that drug-related policing can undermine the protective effects of HIV harm reduction services (Cooper et al., 2012) i.e,., syringe exchange sites, and programs, these findings suggest law enforcement racial policing and drug laws in highly resourced neighborhoods.

Ethical statement

The Emory University Institutional Review Board approved study protocols. Additionally, all state and local jurisdictions participating in NHBS obtained human subject protections approval before conducting the 2009 NHBS survey among PWID. CDC approved NHBS activities and this study protocol.

Author statement

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101486.

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