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Short communication

Examining the neighborhood-level socioeconomic characteristics associated with fatal overdose by type of drug involved and overdose setting

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HIGHLIGHTS

- Stimulant overdoses were in areas high in poverty and low in educational attainment.
- Overdose death rates were predicted by socioeconomic disadvantage.
- Drug overdose deaths were 1.75 times more likely to occur at-home.
- Heroin and polysubstance stimulant-heroin overdoses differed by overdose setting.
- Areas high in structural disadvantage may be ideal targets for intervention.

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ABSTRACT

Background: Fatal drug overdose in the United States is a public health crisis fueled by increased opioid and polysubstance use. Few studies have compared the neighborhood-level socioeconomic characteristics associated with overdoses of various substance classes and, to our knowledge, no investigation has yet assessed these factors in relation to polysubstance overdoses. Further, no study has determined whether socioeconomic conditions predict other contextually relevant aspects of overdoses such as whether they occur at-home or out-of-home.
Methods: Overdose data (2015–2018) were obtained from the Coroner/Medical Examiner's Office of Jefferson County, Alabama. The toxicology results of decedents with a known overdose locations (N = 768) were assessed for the presence of synthetic opioids, natural and semi-synthetic opioids, heroin, stimulants, benzodiazepines, and alcohol. Socioeconomic characteristics were obtained from the Unites States Census Bureau at the census tract level.
Results: Stimulant overdoses occurred in neighborhoods with the highest rates of disadvantage relative to other substance and polysubstance overdose types. The majority of included overdoses occurred at-home (63.7%) and an index of socioeconomic disadvantage predicted overdose rates for both at-home and out-of-home overdoses. Heroin overdose deaths were more likely to occur at-home while polysubstance stimulant-heroin overdoses were more common out-of-home.
Conclusions: An index of socioeconomic disadvantage was generally predictive of overdose, regardless of the setting in which the overdose occurred (in-home vs. out-of-home). The associations between neighborhood-level socioeconomic characteristics and fatal overdose can be tailored by substance type to create targeted interventions. Overdose setting may be an important consideration for future policy efforts, as overdoses were nearly twice as likely to occur at-home.

1. Introduction

Drug overdose is the leading cause of accidental death in the United States and has significantly contributed to a decline in life expectancy from 2015 to 2018 (Hedegaard, Miniño, & Warner, 2020). High mortality rates are driven primarily by opioids, which account for nearly

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70% of overdoses, and by dramatic increases in polysubstance use (National Institute on Drug Abuse, 2019). In 2016, almost 80% of opioid related overdoses involved another class of substances including stimulants, benzodiazepines, or alcohol (Jones, Einstein, & Compton, 2018). Polysubstance use is understudied compared to independent classes of controlled substances despite being associated with worse health outcomes and more frequent high-risk behaviors (Lorvick, Browne, Lambdin, & Comfort, 2018; Morley, Ferris, Winstock, & Lynskey, 2017).

Areas of greater socioeconomic disadvantage are disproportionally impacted by fatal overdose (Frankenfeld & Leslie, 2019; Hembree, Galea, & Ahern, 2005; Pear, Ponicki, & Gaidus, 2019). Pear et al. (2019) for example, found higher rates of poverty and low educational attainment were related to prescription opioid overdoses across 17 U.S. states from 2002 to 2014. Similarly, an assessment of opioid overdoses and naloxone reversals in San Francisco noted that incidents were more common in areas with greater income disparities and higher population density (Rowe et al., 2016). While the relationship between these neighborhood-level factors and opioid overdose have been well established, few studies have yet compared the socioeconomic variables associated with overdoses of different substances and no study, to our knowledge, has assessed this in cases of polysubstance overdose.

The present study sought to amend this gap in the literature in order to shed light on the specific socioeconomic climates that relate to fatal overdoses of common substance categories including synthetic opioid, heroin, natural and semi-synthetic opioid, stimulant, and polysubstance. Decedent cases were examined in Birmingham (Jefferson County), Alabama's largest city. Jefferson County is demographically similar to many metropolitan counties across the U.S. (53.2% Caucasian; 43.6% African American) and has rates of overdose akin to metropolitan counties in the southern U.S. and Appalachia that have been heavily afflicted by the overdose epidemic (Bureau, 2019; Rankings, 2020). Additionally, relevant contextual factors associated with overdose incidents, such as whether they occurred at-home or out-of-home, were investigated. A multi-state review in 2010 indicated that over half of prescription opioid deaths occurred at-home (Easterling, Mack, & Jones, 2016). We hypothesized there are fundamental differences in the social and economic factors at play within the immediate neighborhood environment of those who fatally overdose at-home and those who do not. As such, secondary aims of this study were to examine whether socioeconomic conditions predicted rates of overdose death in each setting (at-home vs. out-of-home) and whether the involvement of specific substances differed between settings.

2. Methods

Decedent records for accidental drug overdose deaths that occurred in Jefferson County, Alabama (2015–2018; N = 915) were obtained from the Coroner/Medical Examiner's Office. The researchers excluded cases for three reasons: 1) toxicology results were inconclusive or unspecified (n = 62), 2) cases, including homeless and transient populations, lacked a valid address (n = 68); and 3) addresses were outside Alabama (n = 17). This resulted in 768 valid cases of overdose in which acute toxicology from one or more substances was the primary cause of death. For categorization purposes, substances were included whether they were directly implicated in cause of death or as a contributing factor. Cases involving only one substance group fell primarily into four categories: synthetic opioid (e.g. fentanyl, fentanyl analogs, tramadol, methadone; n = 100), heroin (n = 115), natural and semi-synthetic opioid (e.g. morphine, oxycodone, hydrocodone; n = 27), and stimulant (e.g. cocaine, methamphetamine; n = 106). Over half of cases were polysubstance overdoses (n = 409). These contained two or more of the former categories of substances in addition to alcohol or benzodiazepines (e.g. diazepam, alprazolam). Because there were over 40 distinct polysubstance combinations, only those with more than 20 occurrences were included in analyses (see Table 1).

Socioeconomic variables were obtained from the U.S. Census Bureau's American Community Survey 5-year Estimates at the tract (e.g. neighborhood) level (United States Census Bureau, 2019). ACS variables included: percentage of total households receiving Supplemental Nutritional Assistance (SNAP), median household income (reverse coded), percentage of vacant homes, and percentage of rented homes, as well as population characteristics: percentage of persons 18 and older with less than a high school education (low educational attainment), percentage of persons below poverty level, and percent unemployment for persons over 16. Population density (number of persons per mile^2) was used as a control. Because of strong correlations among socioeconomic variables, a principal component analysis was utilized to identify latent characteristics within these factors and Cronbach's alpha to evaluate internal consistency. Population variables were then standardized and indexed as a single measure of socioeconomic disadvantage.

At the neighborhood-level, a rate of fatal overdose per 10,000 persons (over the age of 18) was calculated for each census tract containing one or more overdoses. Overdose setting was coded by comparing decedents' overdose location and their residential address. Cases were coded as at-home if these two locations matched and out-of-home if the overdose location was anywhere other than their established residential address, such as a commercial location, intersection, or a different residential address.

Due to previously established association with opioid overdose (Pear et al., 2019), low educational attainment and poverty level were included in ANOVA procedures to determine if rates differed across overdoses of different substances. In secondary analyses, these two measures were part of the disadvantage index, reducing the interpretability of their respective relationship with fatal overdoses but allowing for the inclusion of additional socioeconomic variables. Linear regression analyses were then conducted to examine the amount of variance in census tract overdose rates accounted for by socioeconomic disadvantage in each setting. Assumptions for multiple linear regression were assessed prior to conducting formal analyses. Aside from the presence of a few univariate and multivariate outliers, no assumptions were violated. No transformations were performed and original data were maintained, as the outliers reflect representative values of the studied population. Finally, chi-square tests were employed to assess differences in at-home and out-of-home overdose deaths by substance category.

3. Results

Decedents were predominately Caucasian (71.9%; African American: 27.9%), males (69.9%), and had a mean age of 40.33 (SD = 12.2) years. Broadly, across single and polysubstance categories, opioids were the most commonly implicated substance class, present in 83.5% of cases, followed by stimulants (37.5%). Moving to the neighborhood-level results of the omnibus ANOVA tests, neighborhoods where fatal overdoses occurred differed significantly in both poverty level ($F(8,547) = 3.87$, $p < .001$) and low educational attainment ($F(8,547) = 4.14$, $p < .001$). These findings, however, depended on the substance or substance combinations present in decedents. Post hoc comparisons revealed that, relative to other substances, stimulant overdose deaths occurred in neighborhoods with the highest poverty levels and lowest educational attainment. Low educational attainment was significantly more common in neighborhoods where stimulant overdoses occurred as compared to those where single-substance opioid overdoses took place as well as heroin-stimulant and heroin-alcohol polysubstance combination overdoses. Similarly, the percent of individuals living below the poverty threshold was significantly higher in neighborhoods where stimulant overdoses occurred relative to those in which heroin, synthetic opioid, and synthetic opioid-benzodiazepine combination overdoses took place. See Table 1 for fully delineated post hoc comparison results.

Table 1
Post hoc comparisons of substance categories by socioeconomic factors.

	Substance (n)	Mean	Mean Difference	Standard Error	*p*-value
Low Educational Attainment					
	Stimulant (107) †	15.78%			
	Synthetic Opioid/Stimulant (40)	13.76%	2.03%	1.27	1.00
	Synthetic Opioid/Heroin (57)	13.01%	2.77%	1.12	0.498
	Heroin (115)	12.54%	3.24%	0.91	0.016*
	Synthetic Opioid (100)	12.31%	3.47%	0.95	0.010*
	Synthetic Opioid/Benzodiazepine (26)	11.66%	4.12%	1.50	0.218
	Heroin/Stimulant (51)	11.48%	4.30%	1.16	0.009*
	Heroin/Alcohol (33)	10.55%	5.24%	1.36	0.005*
	Natural & Semi-synthetic Opioids (27)	9.83%	5.96%	1.47	0.002*
Below Poverty					
	Stimulant (107) †	26.99%			
	Synthetic Opioid/Stimulant (40)	25.05%	1.94%	0.03	1.00
	Heroin/Alcohol (33)	23.84%	3.15%	0.03	1.00
	Heroin/Stimulant (51)	22.43%	4.56%	0.02	1.00
	Synthetic Opioid/Heroin (57)	20.90%	6.08%	0.02	0.229
	Heroin (115)	20.19%	6.79%	0.02	0.007*
	Synthetic Opioid (100)	18.81%	8.18%	0.02	0.001*
	Natural & Semi-synthetic Opioid (27)	17.75%	9.24%	0.03	0.058
	Synthetic Opioid/Benzodiazepine (26)	17.25%	9.74%	0.03	0.038*

Note. * indicates *p*-value of less than 0.005; † indicates reference category.

Table 2
Neighborhood-level overdose rates and socioeconomic characteristics by setting and countywide.

	At-Home Overdose (n = 489)	Out-of-Home Overdose (n = 279)	Average for Jefferson County, AL
	Mean (SD)	Mean (SD)	Mean (SD)
Rate of overdose per 10,000 persons	21.8 (12.6)	27.1 (14.4)	23.7 (13.5)
SNAP	14.7% (10.1%)	17.1% (10.2%)	15% (9.9%)
Vacancies	15.6% (7.8%)	17.8% (8%)	14.6% (8.5%)
Rentals	31.1% (16.6%)	39.0% (17.8%)	37.2% (22.1%)
Low Education	12.9% (18.8%)	13.6% (7%)	10.6% (7.4%)
Median Income	$48,078.6 ($24,372.2)	$41,270.6 ($21,774.9)	$49,328 ($27,951.7)
Below Poverty	20.7% (13.3%)	25.0% (14.2%)	17.6% (13.7%)
Unemployment Rate	9.2% (6%)	10.7% (6.3%)	7.7% (6.3%)
Population Density	1,779.5 per mi^2 (1,564.5)	1,968.8 per mi^2 (1,522.4)	593.5 per mi^2 (1,554.7)

Across 768 cases, 489 (63.7%) decedents overdosed at-home and 279 (36.3%) overdosed out-of-home. Neighborhood overdose deaths rates per 10,000 persons, in addition to socioeconomic variables, were separated by setting and are described in Table 2. A principal component analysis of all included socioeconomic variables revealed one latent factor (socioeconomic disadvantage), which had an Eigenvalue of 4.89 and explained 61.06% of the model variance. The reliability of this measure was examined using Cronbach's alpha, which indicated strong internal consistency ($\alpha = 0.92$). Multiple regression analyses assessed the relationship between rates of neighborhood overdose deaths and socioeconomic disadvantage for both at-home and out-of-home overdoses. Neighborhood population density was included as a covariate in analyses. The overall model was statistically significant ($R^2 = 0.29$, $F(2,486) = 99.27$, $p < .001$) with socioeconomic disadvantage ($\beta = 0.57$, $p < .001$; CI = 0.49, 0.65) accounting for 28.7% of the variance in at-home overdoses while controlling for population density ($\beta = -0.22$, $p < .001$; CI = −0.30, −0.14). Similarly, 31.5% of the variance ($R^2 = 0.32$, $F(2,276) = 63.40$, $p < .001$) in out-of-home overdoses was accounted for by socioeconomic disadvantage ($\beta = 0.58$, $p < .001$; CI = 0.50, 0.72) while controlling for population density ($\beta = -0.15$, $p = .004$; CI = −0.27, −0.05).

Chi square results on whether substance and polysubstance categories differed by overdose setting found overdoses involving heroin ($X^2 = 4.227$, $p = .046$) to be more likely to occur at-home. However, polysubstance heroin-stimulant overdoses were more likely to occur out-of-home ($X^2 = 8.148$, $p = .006$). Overdoses involving synthetic opioids and semi-synthetic and natural opioids did not differ by setting nor did any polysubstance combinations involving these substances, alcohol, or benzodiazepines.

4. Discussion

The current study sought to examine the relationship between neighborhood-level socioeconomic characteristics and contextually relevant features of overdose, such as substance type and overdose setting. Opioids were the most common substance involved in overdoses, present in more than 80% of cases. Results from 768 decedents indicated that stimulant overdoses occurred in neighborhoods with the highest rates of poverty and lowest educational attainment relative to other substances and polysubstance combinations. Further, an index of socioeconomic disadvantage predicted overdose rates, regardless of the setting in which an overdose occurred. Fatal heroin overdoses were more likely to occur at-home while polysubstance stimulant-heroin overdose deaths were more common out-of-home.

Considering overdose setting, our study found that at-home overdose deaths were more than 1.75 times more likely than out-of-home. This rate is substantially larger than what has been previously reported, where at-home overdoses were 1.25 times more common across 12 U.S. states during a 3-year period (Easterling et al., 2016). With the rate of at-home overdoses escalating, it is critical to consider prevention strategies that can be effectively implemented behind closed doors. Opioid overdoses in general remain prolific (New Data Show, 2020) and our study found heroin overdoses specifically to more commonly occur at-home. As such, increasing take-home naloxone access and encouraging the participation of cohabitating friends or family members could mean a potentially life-saving line of defense. Existing naloxone programs

have found friends and family members responsible for 10–20% of all overdose reversals (Bagley, Forman, Ruiz, Cranston, & Walley, 2018; Wheeler, Jones, Gilbert, & Davidson, 2014). If their participation in naloxone education and distribution programs were to become commonplace, this may substantially curtail at-home overdose deaths.

The current study found that overdose rates, both at-home and out-of-home, were significantly influenced by the level of structural disadvantage in the neighborhoods where they took place. While the level of disadvantage is difficult to alleviate in the short-term, the identification of these communities provides the opportunity to strategically allocate resources within high-risk neighborhoods. For instance, as stimulant overdoses most frequently occurred in communities with the greatest socioeconomic disparities these areas would be ideal targets for overdose psychoeducation or prevention initiatives. Although out-of-home overdoses occur less frequently, housing substance use resources in high-traffic public venues will likely reach the greatest number of individuals and reduce overdose rates across settings. Such programs could be further tailored using geographic information system strategies, which have been successfully employed to identify community features that correlate with substance use behavior (Barnum, Campbell, Trocchio, Caplan, & Kennedy, 2016; Butz & Streetman, 2018; Hembree et al., 2005; McCord & Ratcliffe, 2007). This data-driven approach would allow resources to be placed with great specificity in the commercial or public spaces (e.g. methadone clinics, bus stops, or liquor vendors) that are in closest proximity to overdose hotspots.

Lastly, our study provides a novel approach for the classification of polysubstance overdoses by assessing both the type and quantity of substances involved in overdose. Polysubstance categorization is difficult given the number of potential substance combinations (48 in this study) and consequently, it is often defined as a single construct. While the incorporation of each unique combination into a statistical model may not be a feasible approach, our study examined only the most commonly presenting substance combinations. This method allowed us to account for variation between poly and single-substance combinations and indeed, significant differences in measures of socioeconomic disadvantage were found between neighborhoods where cocaine overdoses occurred relative to other substance categories. This finding indicates that there is deviation in the social factors that drive various forms of polysubstance use. Future studies should continue to investigate common profiles of polysubstance use and advance methodologies for comparing distinct substance combinations.

This study is not without limitations. The rate of opioid overdose in Jefferson County (83.9%) for this period is almost 16% above the national average and may not be representative of areas of the country less affected by the opioid epidemic (Wilson et al., 2020), limiting generalizability. Because census tracts throughout the entirety of the county were included in analyses, there was also a high degree of variability within the included socioeconomic factors. The percent of individuals below poverty level, for instance, ranged from 1 to 68% across the included neighborhoods. This is indicative of the economic disparities across the greater Birmingham area and the indiscriminate pattern of overdose in the county. Additionally, although cases were excluded for known suicides, we cannot know if decedents were intending to purposefully overdose without clear evidence of intentionality. Future research could focus on the case inclusion/exclusion criteria in spatial analyses of fatal overdoses to examine the robustness of findings.

This study explored the relationship between neighborhood-level socioeconomic characteristics and overdoses of various substance types. It also provides a contemporary examination of at-home and out-of-home overdose rates at the neighborhood level. Future studies and policy efforts should consider the larger neighborhood profiles of at-home and out-of-home overdoses when developing treatment and prevention strategies.

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CRediT authorship contribution statement

Keith Chichester: Conceptualization, Data curation, Formal analysis, Writing - original draft. **Grant Drawve:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Michelle Sisson:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Brandi McCleskey:** Supervision, Writing - review & editing. **Daniel W. Dye:** Supervision, Writing - review & editing. **Karen Cropsey:** Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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