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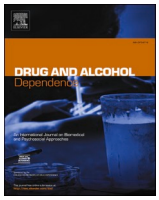

Short communication

State-level homelessness and drug overdose mortality: Evidence from US panel data

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ABSTRACT

Background: Although homelessness is a well-documented risk factor for drug overdose at the individual level, less is known about state-level homelessness and overdose mortality in the United States (US).
Methods: This study used 2007–2020 panel data for all US states and the District of Columbia, from the following sources: US Department of Housing and Urban Development (homelessness data); Centers for Disease Control and Prevention (drug overdose death counts, population estimates, and opioid prescribing rates); Bureau of Labor Statistics (unemployment rates); and the National Forensic Laboratory Information System (drug seizure data). Two-way (state and year) fixed effects models regressed log-transformed drug overdose mortality rates on homelessness prevalence, in nested models adding demographic composition and unemployment measures, as well as drug supply measures. Models were weighted by state population size, and standard errors (SEs) were clustered at the state level.
Results: Homelessness prevalence was significantly and positively associated with rates of drug overdose mortality after adjusting for nationwide trends, time-invariant differences between states, demographic composition, and unemployment rates (b[SE]=0.98[0.36], p=0.009). The positive association between homelessness prevalence and overdose mortality was attenuated at higher levels of fentanyl availability (fentanyl involvement in drug seizures; interaction term b[SE]=−0.02[0.01], p=0.001).
Conclusion: The positive association between state-level homelessness and drug overdose mortality suggests that policies and programs to prevent and reduce homelessness represent fundamental elements of a comprehensive response to the US overdose crisis.

1. Introduction

Drug overdose deaths have increased exponentially in the United States (US; Jalal et al., 2018), rising from 16,849 deaths in 1999 to 106,699 deaths in 2021 (Centers for Disease Control and Prevention; CDC, 2023) and calling attention both to drug availability and underlying social determinants of drug use and related risks (Cerdá et al., 2021). Homelessness and housing instability have been identified as risk factors for fatal or nonfatal overdose among people who inject drugs (Jenkins et al., 2011; O'Driscoll et al., 2001; Park et al., 2018; Sherman et al., 2007; Wagner et al., 2015), and drug overdose is a leading, and increasing, cause of death among individuals experiencing homelessness (Baggett et al., 2013; Cawley et al., 2022; Dickins et al., 2023; Fine et al., 2022; Fliss et al., 2022; Funk et al., 2022; Nicholas et al., 2021). Relative to the general population, drug overdose mortality rates are more than ten times as high in samples of individuals experiencing homelessness across different US communities (Baggett et al., 2015; Fliss et al., 2022; Fine et al., 2022; Rowe et al., 2019; Scott et al., 2022). At the same time, despite the abundance of individual-level evidence regarding homelessness and overdose, it is unclear whether an association between homelessness and overdose mortality is also observed at the *state* level.

Several state- or county-level housing measures (e.g., eviction rates, rental stress, and vacant housing units) are positively associated with drug overdose mortality (Bradford and Bradford, 2020; Monnat, 2018; Monnat et al., 2019), while other housing-related measures (e.g., house prices, mobile homes, group quarters, Brown and Wehby, 2019; Frankenfeld and Leslie, 2019) are negatively associated with drug overdose mortality rates. Due to the complex and multifactorial relationships between socioeconomic factors and community overdose mortality rates, county-level research has yielded mixed results

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regarding associations between overall poverty measures and overdose mortality (Cano et al., 2023), and much less is known regarding *homelessness* specifically. Therefore, the present study examines the relationship between state-level rates of homelessness and US drug overdose mortality.

2. Methods

2.1. Data Sources and Measures

2.1.1. Homelessness Data

Estimated numbers of individuals experiencing homelessness, in each state each year (2007–2020), were obtained from the US Department of Housing and Urban Development (HUD) Point-in-Time count, which is undertaken each year at the end of January to provide official estimates of individuals experiencing homelessness (sheltered and unsheltered). Detailed information about methodology used in Point-in-Time counts is published elsewhere (US Department of Housing and Urban Development, 2014), and a description of this data source is also provided in Supplemental Table S1, which details all measures used in the study.

2.1.2. Mortality Data

Numbers of individuals who died of drug overdoses in each state each year, as well as age-adjusted mortality rates, were obtained via the Centers for Disease Control and Prevention's (CDC) Multiple Cause of Death dataset (CDC, 2023) via the WONDER online platform, which provides death certificate information for deaths of US residents that occurred in the 50 states or DC. Drug overdose deaths were identified via any underlying cause of death code within ICD-10 categories X40–44 (accidental drug poisoning), X60–64 (intentional drug self-poisoning), X85 (homicide via drug poisoning), or Y10–14 (drug poisoning of undetermined intent). Analyses included drug overdoses involving any drug to avoid the bias introduced by geographic variation in drug reporting on death certificates (Jones et al., 2019).

2.1.3. Population estimates and covariates

Population estimates for each state each year were obtained from the National Center for Health Statistics' intercensal estimates of the July 1st resident population, accessed via the WONDER online platform (CDC, 2023). Population estimates for Black, White, American Indian/Alaska Native, non-elderly adult (ages 18–64), and metropolitan populations were also used to calculate the demographic composition of each state each year (e.g., percent Black, percent ages 18–64; see Table S1). Unemployment rates for each state each year were drawn from the US Bureau of Labor Statistics Local Area Unemployment Statistics program (US Bureau of Labor Statistics, 2023). The number of opioid prescriptions dispensed per 100 residents, for each state each year, was derived from the CDC (CDC, 2021), while numbers of drug seizure cases in each state each year, overall and involving fentanyl/fentanyl analogs, were obtained from the Public Data Query System of the US Department of Justice National Forensic Laboratory Information System (NFLIS, 2023).

2.2. Analyses

Analyses were completed in Stata/MP 16.1 and RStudio. Using panel data (for all 50 states and DC, for the years 2007–2020), *homelessness prevalence* (number of individuals experiencing homelessness in any given state, divided by state population size, multiplied by 100) was modeled as a predictor of the outcome of interest, the *drug overdose mortality rate* per 100,000 population (log-transformed), using two-way fixed effects Ordinary Least Squares regression models (Allison, 2009). In these models, state fixed effects adjust for time-invariant differences between states, while year fixed effects adjust for nationwide events or changes over time that affect all states. Estimates were weighted based on state population size, and standard errors (SEs) were clustered at the state level.

Model 1 included the predictor and outcome variable; Model 2 adjusted for time-varying demographic composition measures (percent: Black; White; American Indian; ages 18–64; and in metropolitan areas) and unemployment rates. The final model, Model 3, included the previously-mentioned time-varying demographic composition and unemployment measures, as well as two time-varying drug supply measures: 1) number of opioid prescriptions per 100 residents; and 2) percent of drug seizures involving fentanyl, as an interaction term with homelessness prevalence. This interaction was modeled in consideration of the potential for high availability of illicitly-manufactured fentanyl to compound pre-existing overdose risks in populations experiencing homelessness, and based on prior research identifying fentanyl availability as a moderator of the association between a county-level measure of socioeconomic hardship and overdose mortality (Dean and Kimmel, 2019).

3. Results

Descriptive statistics for all variables are provided in Table 1, and values of the outcome and predictor are plotted in Supplemental Figures S1-S2. Table 2 presents results from the two-way fixed effects regression models predicting drug overdose mortality rates based on homelessness prevalence. Homelessness prevalence was significantly and positively associated with drug overdose mortality rates after adjusting for time-invariant state differences and differences over time that are constant between states (Model 1, $b[SE]=0.92[0.38]$, $p=0.019$) and after including time-varying state demographic composition and unemployment measures (Model 2, $b[SE]=0.98[0.36]$, $p=0.009$). As reflected in Model 3, which added time-varying drug supply measures, the positive association between homelessness prevalence and drug overdose mortality was attenuated at higher levels of fentanyl involvement in drug seizures (interaction term $b[SE]=-0.02(0.01)$, $p=0.001$). A graphical representation of this interaction is provided in the Supplemental Material (Figure S3), along with results from the sensitivity analyses modeling age-adjusted mortality rates instead of crude rates (Table S2), for which results were nearly identical.

4. Limitations

HUD Point-in-Time counts represent the official source of US homelessness data, yet these counts likely underestimate homelessness, due to the challenge of counting unsheltered populations and the definition of homelessness used, which does not include individuals experiencing housing instability or sharing living accommodations (Fusaro et al., 2018; Mosites et al., 2021). Counting only those experiencing

Table 1
State-Level Descriptive Statistics for 714 State-Years, United States 2007–2020.

	Mean (SD)	**Range [Min, Max]**
Drug Overdose Mortality Rate, per 100,000[a]	17.30 (8.77)	[2.34, 74.52]
Homelessness Prevalence, per 100 Residents	0.18 (0.16)	[0.04, 1.23]
Percent Population Aged 18–64	62.22 (1.92)	[57.92, 71.81]
Percent Black Population	12.28 (10.95)	[0.67, 55.97]
Percent White Population	80.47 (12.91)	[30.07, 97.03]
Percent AI/AN Population	2.17 (3.29)	[0.22, 17.55]
Percent in Metropolitan Area	76.31 (18.16)	[29.59, 100.00]
Unemployment Rate, per 100 Labor Force	5.96 (2.27)	[2.10, 13.80]
Opioid Prescriptions, per 100 Residents	73.31 (24.85)	[25.00, 146.90]
Percent Drug Seizures Involving Fentanyl	5.78 (12.86)	[0.00, 81.91]

Notes. [a]Crude rate for drug overdose deaths of any intent, involving any drug. *Abbreviations*. SD, standard deviation; Min, minimum value; Max, maximum value.

Table 2
Results of Two-Way Fixed Effects Models Predicting Drug Overdose Mortality Rates Based on Homelessness Prevalence, for 50 US States/DC, 2007–2020 (n=714 state-years).

	Model 1		Model 2		Model 3	
	b (SE)	*p* value	*b* (SE)	*p* value	*b* (SE)	*p* value
Homelessness prevalence	0.92 (0.38)	0.019	0.98 (0.36)	0.009	0.63 (0.31)	0.046
Percentage drug seizures involving fentanyl					0.02 (0.00)	<0.001
Homelessness prevalence × Percentage drug seizures involving fentanyl					-0.02 (0.01)	0.001
Opioid prescribing rate					Yes	
Demographic composition measures			Yes		Yes	
Unemployment rate			Yes		Yes	
State fixed-effects	Yes		Yes		Yes	
Year fixed-effects	Yes		Yes		Yes	
Population weighted	Yes		Yes		Yes	
R^2	0.71		0.75		0.84	
BIC	-465.96		-544.25		-845.75	

Notes. Standard errors clustered at the state level. All models are weighted by state population size. Rates of drug overdose mortality (outcome) are log-transformed and per 100,000. Homelessness prevalence is per 100 residents. Opioid prescribing rate is per 100 residents. R-squared for the within estimator.
Abbreviations. SE, robust standard error; BIC, Bayesian information criterion.

homelessness on one given day also limits the scope of the estimates (Fusaro et al., 2018), and state-level counts may be influenced by seasonal migration patterns (Almquist et al., 2020). Furthermore, although bound by HUD minimum standards, Point-in-Time counts in different jurisdictions include different methodologies (e.g., censuses, sampling strategies, and extrapolation) which may change over time (Schneider et al., 2016; Tsai and Alarcón, 2022).

Due to data availability, the study's analyses were limited to the years 2007–2020 and to the state level, instead of more granular geographic units. The analyses aimed to adjust for several observed and unobserved sources of confounding within and between states, yet the number of controls included was limited by the number of state-year observations. Finally, percent of drug seizure cases involving fentanyl/analogs was modeled as a proxy of the extent to which illicitly-manufactured fentanyl is represented in state drug supplies, yet these data do not include all drug seizures or drugs not seized by law enforcement, nor do they account for the relative size of each drug seizure (National Forensic Laboratory Information System, n.d.).

5. Discussion

While drug overdose mortality has increased exponentially in the US (Jalal et al., 2018), homelessness has followed a different trajectory, declining after the years of the Great Recession and beginning to increase again after 2016 (De Sousa et al., 2022). Based on state-level panel data from 2007 to 2020, the present study's findings offer initial evidence of a state-level association between increased homelessness prevalence and increased rates of drug overdose mortality in the United States. This association was observed even after adjusting for time-invariant state differences, changes over time affecting all states, yearly state-level unemployment rates, demographic composition measures, and opioid prescribing rates, although the association was attenuated at higher levels of fentanyl involvement in drug seizures.

Considering that individuals experiencing homelessness die of drug overdoses at notably higher rates than the general population (Fine et al., 2022; Scott et al., 2022), an increase in the proportion of the population experiencing homelessness could be expected to translate into an increase in the overall population overdose mortality rate, due to demographic composition change. At the same time, it is also possible that state levels of homelessness exert indirect effects on overdose mortality rates, potentially involving community levels of drug use and drug commerce (Werb et al., 2008), local economic and social spillover effects, medical system strain (Abramson et al., 2021), and resource allocation. Overall, overdose mortality rate differences between states, and within states over time, likely represent the interplay of numerous risk and protective factors, including both supply-side factors such as non-pharmaceutical fentanyl availability, socioeconomic vulnerabilities such as homelessness, demographic and regional patterns, and policies and resources.

The study's finding that the association between state homelessness and overdose mortality was stronger at lower levels of fentanyl involvement in drug seizures may seem counterintuitive, considering that illicitly-manufactured fentanyl may be highly accessible to individuals experiencing homelessness, as it is relatively inexpensive and sold on the street. At the same time, individuals experiencing homelessness are not the only population demographic exposed to fentanyl, which has nearly replaced heroin supplies in the eastern US (Pardo et al., 2021) and has also recently proliferated in the form of counterfeit tablets, particularly in the West (Kilmer et al., 2022), broadening the drug's demographic reach. Determining optimal measures of street fentanyl availability, in light of limitations in drug seizure data measures (McBrien and Alexander, 2022), is critical for understanding the interplay between drug availability and social disadvantage measures such as homelessness. Moreover, additional research is necessary to elucidate potential pathways and moderators between state-level homelessness and overdose, to differentiate between various types of homelessness (e.g., unsheltered, different types of shelter housing, chronic homelessness, family homelessness), and to incorporate the role of racial disproportionality (Jones, 2016) or examine COVID-related changes.

Homelessness prevention strategies include rental subsidies, eviction prevention programs (Doran et al., 2022), and safety net programs, as well as policies related to zoning, construction, and taxes (Byrne et al., 2013). With respect to improving housing outcomes, including among individuals experiencing chronic homelessness and co-occurring substance use and mental disorders (US Department of Housing and Urban Development, 2007), Housing First's effectiveness (Baxter et al., 2019; Tsai, 2020) and cost-effectiveness (Jacob et al., 2022) is well-documented. Overall, the association between homelessness and overdose mortality suggests that policies and programs to prevent and reduce homelessness represent a fundamental component of a comprehensive response to the ongoing crisis of drug overdose deaths in the US (Doran et al., 2022).

6. Conclusion

Homelessness is not the only risk factor for overdose mortality, nor is it likely among the largest contextual influences on state overdose rates. Nonetheless, the present study documented a positive association between state-level homelessness prevalence and drug overdose mortality rates in the US, 2007–2020, even after accounting for levels of unemployment and other differences between states and years. Study findings add to literature at the individual level concluding that not only is preventing and addressing homelessness a priority in and of itself, but also a priority relevant in efforts to address overdose mortality.

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Author note

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CRediT authorship contribution statement

Manuel Cano: Conceptualization; Methodology; Data curation; Formal analysis; Writing – original draft; Visualization. **Sehun Oh:** Conceptualization; Validation; Writing – review & editing.

Declaration of Competing Interest

No conflict of interest declared by the authors.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2023.110910.

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