BACKGROUND

Drug-related mortality, morbidity, and dependence have increased exponentially in the U.S. over the past four decades.[1] Over the same four decades, the occurrence of disasters and extreme weather events also increased, including hurricanes,[2] extreme heat events and wildfires,[3] winter weather instability,[4] and flooding.[5] In almost all cited cases, predictions indicate a worsening pattern of disasters, as human-attributed climate change and other anthropogenic influences (e.g., unsustainable land use patterns) remain key drivers of these phenomena and are unlikely to be ameliorated in the short term. Despite this evidence of continued increases in disasters as well as associated substantial economic costs,[6] we know less about the impacts of disasters on public health, especially as related to substance use. Here, we examine the degree to which these two increasing trends, drug-related mortality and disasters, are related in order to identify how drug problems may be exacerbated in communities that experience disasters.

To understand how disasters have an effect on health outcomes such as substance use and mortality, we use a Big Events perspective as a guiding theoretical model.[7] Big Events are periods during which ordinary life is disrupted, often constituting abnormal events, which can occur progressively over time or occur acutely,[7] with one theoretical commentary making explicit how a natural disaster represents a Big Event with its own set of pathways that ultimately affect substance use.[8] In particular, disasters can cause disruptions to treatment access and other health promoting resources as well as increase psychological distress that may subsequently lead to acute drug-related outcomes, including mortality. By contrast, disasters may also disrupt drug markets, resulting in fewer adverse drug-related outcomes. In the case of substance use, arguably no other U.S.-based natural disasters have been studied to the extent of Hurricanes Katrina and Rita, which made landfall in the southeastern U.S. during the 2005 hurricane season. This

research confirms some of these mechanisms related to treatment access,[9-10] psychological distress,[11-12] and drug market disruption.[13] While existing studies also examine substance use as an outcome,[11-12,14-18] drug-related mortality has not been extensively examined; indeed, disasters tend to be measured by overall mortality rather than examining cause of death.

In sum, the current scholarship on disasters and substance use, as well as health more generally, remains limited to studies of single disasters or limited locations, uses qualitative data with limited generalizability, or cannot parse pre- and post-disaster effects. Moving beyond these micro-level studies, we conduct a comprehensive examination of the effect of a broad range of disasters throughout the U.S. over more than two decades (2000-2023) on drug-related mortality using a novel dataset of disaster occurrence.

METHODS

Data

CDC Restricted-Access Multiple Cause of Death Dataset

To measure deaths due to drug overdoses, we use the CDC's restricted access mortality files from 2000-2023, which contain all deaths in the U.S. Cause-of-death codes allow identification of drug overdoses, which are then aggregated to the county-month level. We use the CDC's definition for drug overdose. Such deaths have ICD-10 underlying cause codes of "drug poisoning" X40-X44, X60-X64, X85, and Y10-Y14. We can further identify specific drug types using the multiple cause of death ICD-10 codes, such as opioids (T40.0-T40.4, T40.6), cocaine (T40.5), benzodiazepines (T42.4), and psychostimulants with abuse potential (T43.6).

Further, other forms of mortality as the primary cause of death can include the same ICD-10 codes as *contributing causes*. Elsewhere,[19-20] we have described these as "psychotropic-drug-implicated mortality," or deaths in which drugs were a contributing cause but not the primary

coded cause of death, which are often overlooked when only examining those coded as drug overdoses. We also examine this outcome separately by external (e.g., traffic accidents, drowning, suicide) and medical deaths (e.g., cardiovascular).

Federal Emergency Management Agency (FEMA) Disaster Declaration Summaries

We use the official FEMA Disaster Declarations dataset, which is available via the OpenFEMA web-based platform.[21] The datasets list all official FEMA Disaster Declarations, beginning with the first disaster declaration in 1953 and featuring all disaster declaration types, thus containing no missing data. These administrative data were re-organized into a county-month dataset to align with the CDC WONDER data. For this manuscript, we use the time period for which we have mortality data (2000-2023). Here, we use a dichotomous measure for whether there was an active disaster declaration in a county in a given month (disaster declarations can last several months) and consider all types of disasters.

Analysis

Our outcomes represent the count of drug-related deaths in a month in a county. Thus, we use negative binomial count models. Our main predictors is an official disaster declaration. Statistically, disasters represent an exogenous shock, allowing for a quasi-experimental approach to determine the causal effect of disasters on drug use outcomes. Our models include a linear fixed effect for year, an exposure offset to adjust for county population, an overdispersion parameter, and cluster-corrected standard errors to account for repeated observations within county. We also show fixed-effect negative binomial models, which measure the within-county effect of disasters rather than the overall population-level effect. We interpret the results using the incident rate ratio, which is the percentage change in deaths during a disaster declaration. We examine the following outcomes: overall overdose mortality; overdose mortality specific to the

following drug types: opioids, cocaine, and psychostimulants; and two forms of drug-implicated mortality: external and medical deaths. In the U.S, there are currently 3,143 counties, for which we use data across 288 months over 28 years, leading to a total sample size of 905,184.

RESULTS

Table 1 shows the results of our negative binomial models. We begin with the population-average models. For all three drug classes, there is a significant positive effect. When a disaster is declared, on average, deaths are 3.9% ($p<.01$), 8.4% ($p<.001$), and 19.8% ($p<.001$) higher for opioids, cocaine, and psychostimulants, respectively. Drug-implicated deaths are 6.4% higher if a disaster is declared ($p<.001$); however, this effect appears limited to medical deaths, which are 13.6% higher during disaster declarations ($p<.001$).

The fixed effects models show similar results, but here the interpretation is within-county relative to months when a disaster is not present. In a given county, compared to months with no disaster declaration, deaths are 3.9%, 10.0%, and 4.9% higher for opioids, cocaine, and psychostimulants, respectively, in months with a disaster declaration ($p<.001$). Similarly, overall drug-implicated deaths are 4.6% higher, and medical drug-implicated deaths are 6.3% higher within the same county when a disaster is declared compared to no declaration ($p<.001$).

CONCLUSION

We find considerable evidence that disasters affect drug-related mortality, measured both as overdoses and psychotropic drug-implicated deaths. Thus, disasters appear to contribute to an escalation in drug-related mortality, and there is a need to enhance resources and support for people who use drugs when disasters occur. The public health implications are urgent and immense, by informing disaster response policies that determine how to deploy resources to reduce secondary mortality and morbidity from substance use when disaster strikes.

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Table 1: Negative Binomial Count Models of Drug-Related Mortality, 2000-2023

	Population-Average Models		Fixed-effects Models	
Outcomes	b (SE)	IRR (SE)	b (SE)	IRR (SE)
Opioids	0.038 (0.011)**	1.039 (0.012)**	0.038 (0.008)***	1.039 (0.008)***
Cocaine	0.080 (0.018)***	1.084 (0.020)***	0.095 (0.014)***	1.100 (0.015)***
Psychostimulants	0.181 (0.020)***	1.198 (0.024)***	0.048 (0.013)***	1.049 (0.013)***
Drug-implicated	0.062 (0.010)***	1.064 (0.010)***	0.045 (0.006)***	1.046 (0.007)***
Drug-implicated: external	-0.016 (0.024)	0.984 (0.023)	-0.018 (0.020)	0.982 (0.020)
Drug-implicated: medical	0.127 (0.027)***	1.136 (0.030)***	0.061 (0.021)**	1.063 (0.023)**

Note: Analytic level is county-month, *N*=905,184. All models also include a linear fixed effect for year, an overdispersion parameter, and an exposure offset for population. Population-average models also include a standard error cluster-correction for county. IRR = incident rate ratio; SE = standard error.
*p<.05, **p<.01, ***p<.001