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What Is Driving the Drug Overdose Epidemic in the United States?

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Abstract

The demand-side perspective argues that the drug overdose epidemic is a consequence of changes in the economy that leave behind working-class people who lack a college education. In contrast, the supply-side perspective maintains that the epidemic is primarily due to changes in the licit and illicit drug environment, whereas a third, distinct perspective argues that income inequality is likely a key driver of the epidemic. To evaluate these competing perspectives, we use a two-level random intercept model and U.S. state-level data from 2006 to 2017. Contrary to the demand-side approach, we find that educational attainment is not associated with drug-related mortality. In support of the supply-side approach, we provide evidence indicating that opioid prescription rates are positively associated with drug-related mortality. We also find that income inequality is a key driver of the epidemic, particularly the lack of resources going to the bottom 20% of earners. We conclude by arguing that considerations of income inequality are an important way to link the arguments made by the demand-side and the supply-side perspectives.

Keywords

deaths of despair, drug overdose epidemic, income inequality, mortality, population health

An abundance of evidence indicates that the drug overdose epidemic in the United States is a national public health emergency (Gomes et al. 2018; Hedegaard, Miniño, and Warner 2018; Kariisa et al. 2019). In 2017, 70,237 drug overdose deaths occurred in the United States, with opioids involved in 67.8% of these fatal poisonings (Scholl et al. 2019). The U.S. drug-related mortality rate (age-adjusted) increased from 6.1 per 100,000 people in 1999 to 21.7 in 2017 (Hedegaard et al. 2018). From 1999 to 2006, the average annual increase in the drug-related mortality rate was 10%, and that rate has risen over time. From 2006 to 2014, the average increase was 3%, which subsequently jumped to 16% from 2014 to 2017 (Hedegaard et al. 2018).

Although opioids are often recognized as the major contributor to drug-related mortality, it is important to note that in 2017, cocaine and other psychostimulants were involved in one-third of the drug overdose deaths in the United States (Kariisa et al. 2019). Three-fourths of the cocaine-involved deaths and one-half of the psychostimulant-involved deaths also included an opioid. Since 2013, drug overdoses involving cocaine and psychostimulants have increased across all demographic groups and U.S. census regions (Kariisa et al. 2019). Thus, the current drug overdose epidemic in the United States appears to be an evolving one that is increasingly characterized by

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polysubstance use (Jones, Einstein, and Compton 2018; McCall Jones, Baldwin, and Compton 2017).

Although drug-related mortality has been increasing for nearly 20 years, there is no consensus about its causes (Case and Deaton 2020; Monnat 2018, 2019; Ruhm 2019). The debate emerges into two broad schools of thought—the demand side versus the supply side. The demand-side perspective, most recently framed as the "deaths of despair" narrative, argues that the current drug epidemic is a product of macroeconomic changes over the past half century that leave behind vulnerable members of the working class who lack a college education (Case and Deaton 2020). In contrast, the supply-side perspective argues that the increase in drug-related mortality is a product of drugs, particularly opioids, becoming more readily available and affordable through both licit and illicit means (Lin, Liu, and Ruhm 2020; Ruhm 2019; Singhal, Tien, and Hsia 2016). Although these two perspectives are often positioned as competing paradigms, a third approach—the income inequality perspective—provides a way to incorporate insights from both approaches because it explains how macrolevel changes in the political economy directly affect individuals and the ways by which they relate to one another. The role of income inequality in the current drug overdose epidemic is given negligible discussion in both the demand-side and the supply-side approaches. However, we argue that drug-related mortality is likely a product of both financial opportunities cultivated by wealthy and powerful elites as well as the vulnerabilities present in the working class, particularly nonmobile and displaced workers.

In the current study, we evaluated these three approaches to understanding the drug overdose epidemic. To do so, we used a panel data set of the 50 U.S. states and the District of Columbia covering the 2006 to 2017 period. We analyzed these data using a two-level random intercept model. In contrast to fixed-effects models that estimate within effects, multilevel models allow for the simultaneous estimation of within and between effects, which permitted us to evaluate how the drivers of the epidemic are associated with drug-related mortality through time and across states.

Before reporting the results of the analysis, we discuss the key arguments made by the demand-side and the supply-side approaches concerning the current drug overdose epidemic and how insights from the income inequality and health literature can potentially serve as a link between the two. Our findings support the arguments made by the supply-side perspective and the inequality–health literature more so than the demand-side approach. However, the effect of income inequality on drug-related mortality is complex. Our findings indicate that the share of income going to the top 5%, the top 20%, and the Gini coefficient are not associated with drug-related mortality but that the share of income of the bottom 20% is associated with drug-related mortality. In other words, and in the context of income inequality, the lack of resources going to the earners at the bottom of the income distribution is driving the drug overdose epidemic. We conclude that a broader discussion of inequality provides a way to integrate the demand-side and the supply-side approaches to enhance our understanding of drug-related mortality.

BACKGROUND

Divergent Perspectives on the Drivers of the Drug Overdose Epidemic

The demand-side perspective. The demand-side perspective argues that the current drug overdose epidemic is a product of macroeconomic changes in the United States beginning in the 1970s (Case and Deaton 2015, 2017, 2020; Dasgupta, Beletsky, and Ciccarone 2017; Monnat 2018). Case and Deaton (2015, 2017, 2020) showed that in some segments of the U.S. population, particularly among middle-aged white men with a high school education or less, there is an association between diminished economic opportunity and increased overall mortality. The phenomenon, recently described as deaths of despair, includes deaths related to drugs, suicide, and alcohol. They argue that this pattern of mortality is a consequence of structural changes in the U.S. economy that have greatly reduced the number of well-paying jobs (particularly in the manufacturing sector), which many once had access to regardless of their level of education (Case and Deaton 2017; Charles, Hurst, and Schwartz 2018).

Scholars working within this framework argue that a variety of processes are behind these jobs disappearing—production moving overseas, the weakening of labor unions, and computer and robotic technology replacing skilled workers (Desilver 2017; Pierce and Schott 2020). These economic changes led to the rise of a postindustrial economy, causing elevated hopelessness and despair (Case and Deaton 2017, 2020). According to Case and Deaton (2020), deaths of despair are primarily restricted to those without a college education regardless of race or gender. Although it is true that deaths of despair are highest among white men without a college degree, deaths of despair have also increased for women and African Americans without a college education (Case and Deaton 2020). Thus, the demand-side approach places significant emphasis on differences in educational attainment to explain the drug overdose epidemic.[1]

The supply-side perspective. The second paradigm used to explain the drug overdose epidemic is the supply-side perspective, which argues that drugs, particularly opioids, have become more readily available since the 1990s (Paulozzi, Mack, and Hockenberry 2014; Pezalla et al. 2017; Ruhm 2019). This perspective argues that although there may be a link between macroeconomic conditions and drug-related mortality, the association disappears once supply-side characteristics are accounted for (Ruhm 2019). Moreover, this approach suggests that the epidemic is not due to changes in the macroeconomic environment for two reasons. First, states with relatively strong economies (e.g., Massachusetts) have experienced high rates of drug-related mortality, and second, whites have a higher drug-related mortality rate than minority groups who have long lived in greater economic precarity (Ruhm 2019).

Moreover, scholars working within this approach point to the increase in drug-related mortality occurring at the same time that opioids started to become more readily prescribed by physicians (Ruhm 2019). The supply-side paradigm highlights the role that pharmaceutical companies play in increasing opioid availability by encouraging physicians to prescribe opioid analgesics (Hadland et al. 2018; Makary, Overton, and Wang 2017). Although the number of prescriptions have declined since 2010, the supply of illicit fentanyl and other opioids, such as heroin, have markedly increased in response (Ruhm 2019). For example, illicit fentanyl, produced in China, has dramatically increased over the past decade (Drug Enforcement Agency 2016; Suzuki and El-Haddad 2017). Thus, the supply-side perspective is primarily focused on the role of specific sectors in the economy—the health care/pharmaceutical industry and the illicit drug industry—rather than changes in the economy as a whole.

The income inequality–health relationship: a framework to integrate the demand-side and supply-side perspectives. Both the demand-side and supply-side perspectives downplay the role of income inequality in the drug overdose epidemic. Case and Deaton (2020) suggested that the rise in inequality is a product of the aforementioned macroeconomic changes, but they did not believe it influences drug-related mortality to any discernable degree. Relying on correlations, they showed that highly unequal states, like California and New York, have relatively low rates of drug-related mortality, whereas more equal states, like New Hampshire, have high mortality rates (Case and Deaton 2020). Similarly, from the supply-side perspective, Ruhm (2019) argued that although demand-side conditions and inequality may explain some portion of the drug epidemic, the overall expanded supply and availability of drugs provides a much stronger explanation for the overdose epidemic.

A large body of research in the social sciences suggests that inequality is a key driver of a range of health-related outcomes (see Pickett and Wilkinson 2015; Wilkinson and Pickett 2010, 2019). Recent studies that used relatively more sophisticated statistical modeling techniques have provided empirical evidence of the detrimental health impacts of macro levels of income inequality, especially reductions in country-level and U.S. state-level average life expectancy (e.g., Curran and Mahutga 2018; Hill and Jorgenson 2018; Jorgenson et al. 2020). A number of studies have also observed inequality to be associated with adult and infant mortality, obesity, HIV infections, mental illness, and homicides (Buot et al. 2014; Daly 2016; Ribeiro et al. 2017; Torre and Myrskylä 2014; Wilkinson and Pickett 2010, 2019). Overall, the majority of these studies suggest that inequality is harmful to human health, well-being, economies, and social cohesion.

Although the demand-side and the supply-side approaches underplay the role of inequality in the drug overdose epidemic, multiple theoretical perspectives that can be applied to drug use help explain why income inequality is related to various population health outcomes (Hill, Jorgenson et al. 2019; Hill and Jorgenson 2018; Jorgenson et al. 2020). The psychosocial and social capital perspectives take a micro point of view to the inequality–health relationship, whereas neomaterialism takes a macro perspective. The psychosocial perspective suggests that the stress of relative deprivation, from the unequal distribution of income, contributes to low self-esteem, emotional distress, and risky coping behaviors, such as drug use (Wilkinson and Pickett 2010).

A similar framework—the social capital perspective—argues that income inequality facilitates widespread status competition, which tends to undermine social cohesion and interpersonal trust and as a consequence, reduces collective political efforts to support vulnerable populations (Kawachi et al. 1997; Truesdale and Jencks 2016). A third approach, the neomaterialist perspective, suggests that income inequality concentrates wealth and power among elites and weakens broader commitments to the general interests of society. These conditions create political pressure to cut taxes, deregulate industry, and limit investments in public resources and social services that promote public health, all of which disproportionately impact those in lower income groups (Neumayer and Plümper 2015).

Although the inequality–health link is a well-established body of research, few empirical investigations have studied the relationship between income inequality and the drug epidemic, and those that have often did so indirectly. Three important studies that either directly or tangentially study the relationship are Monnat (2018, 2019) and Peters et al. (2019). Monnat (2018) found that income inequality (operationalized as the Gini coefficient) is associated with higher rates of drug-related mortality. Monnat (2019), although not explicitly investigating inequality, found that more economically distressed counties have higher drug-related mortality rates. Peters et al. (2019), whom also did not investigate inequality explicitly, found that places hit hardest by the prescription-opioid epidemic are those that have been economically left behind. These studies illustrate that economic distress plays a significant role in the drug epidemic and that supply-side factors also matter, but they only tangentially linked their findings to the unequal distribution of resources and power in society.

The income inequality–health literature and the aforementioned studies by Monnat (2018, 2019) and Peters et al. (2019) also highlight that different parts of the income distribution may affect drug-related mortality more so than others. The inequality–health literature has generally focused on inequality measures that quantify the concentration of income at the top of the distribution or the Gini coefficient that takes into account the entire distribution while giving less attention to the bottom of the income distribution (Hill and Jorgenson 2018; Pickett and Wilkinson 2015; Wilkinson and Pickett 2010). However, the studies by Monnat (2018, 2019) and Peters et al. (2019) suggest that economic distress, or the lack of resources going to earners at the bottom of the income distribution, is driving the epidemic. Thus, whether inequality is associated with drug-related mortality may depend on how inequality is measured.

Even though it has been given limited attention in the drug epidemic literature, we argue that the income inequality–health paradigm can serve as a bridge between the demand-side and supply-side perspectives for four reasons. First, the resources in a society have to be distributed in some way. When they are concentrated at the top of the income distribution, the rich not only have more resources, but also they have the power to influence political decisions (Cole 2018; Saez and Zucman 2019). As the neomaterialist perspective argues, the elite try to actively preserve that power by undermining social welfare programs and legislation that benefit the working class and poor (Hill and Jorgenson 2018; Neumayer and Plümper 2015).

Second, because inequality is a measure of the distribution of social power, higher inequality also means the elite have more economic power relative to everyone else. When the elite have more power, working-class people have less, which is associated with a weakening of labor unions and stagnant wages (Piketty 2014; Saez and Zucman 2019; Stiglitz 2012). The economic distress and alienation that this creates is a key aspect of the demand-side paradigm (Case and Deaton 2020).

Third, from the supply side, higher inequality is directly tied to the rise and reproduction of monopolistic and oligopolistic sectors (Piketty 2014; Saez and Zucman 2019). In the United States, a prime example is the private health care/pharmaceutical industry, which the supply-side approach criticizes for their role in the drug overdose epidemic. However, it should be noted that this industry also produces instability and hardship for people through the very existence of private health care insurance (Saez and Zucman 2019). If we consider health care insurance to be a tax on labor (because it is essentially mandatory), it increases the effective labor tax rate in the United States from 29% to 37%, which disproportionately burdens the poor and working class (Saez and Zucman 2019). In contrast to a tax levied by the government, this money goes primarily to industry executives, which further reproduces inequality.

Fourth, Case and Deaton (2020) suggested that in contrast to what inequality scholars argue, people only compare themselves to those in their surrounding community—not to the elite. However, a long line of research suggests that people *do* compare themselves to the elite and that they do it more so in highly unequal societies (e.g., the United States), which can lead to poor health outcomes (Bourdieu 1984; Schor 1993; Veblen 1994; Wilkinson and Pickett 2010, 2019).

Overall, the arguments made by the demand-side and supply-side approaches suggest that income inequality is central to the underlying arguments of each perspective even though it is given limited recognition by both. We suggest that both approaches are concerned with how the unequal distribution of resources and power drives drug-related mortality and as such should not be considered antithetical. Thus, we believe a focus on income inequality is key to integrating the demand-side and the supply-side approaches.

Given the discussion of the three approaches to the drug overdose epidemic—the demand-side perspective, the supply-side perspective, and the income inequality–health perspective—we test the following hypotheses:

- *The Demand-Side Hypothesis:* Educational attainment is negatively associated with drug-related mortality.
- *The Supply-Side Hypothesis:* The opioid prescription rate is positively associated with drug-related mortality.
- *The Income–Inequality Hypothesis:* The income share of the top 5%, top 20%, and the Gini coefficient are positively associated with drug-related mortality, and the income share of the bottom 20% is negatively associated with drug-related mortality.

DATA AND METHODS

Sample

We analyzed state-level annual observations for the temporal period 2006 to 2017 for the 50 U.S. states and the District of Columbia. The time period of this study corresponds to the first year in which the opioid prescription data were made available by the Centers for Disease Control (CDC 2019) and the last year of available mortality data.

Model Estimation Technique: Two-Level Random Intercept Model

We used a two-level random intercept model to test our hypotheses. Our model nested annual state-level observations within states. In total, 611 observations (Level 1) were nested within the 50 states and the District of Columbia (Level 2) from 2006 to 2017. The two-level random intercept model, also known as the within-between random-effects model (REWB) or the hybrid model,[2] allowed us to model the within and between effects for each driver of drug-related mortality. The model is written as follows:

$$y_{ij} = \beta_0 + \beta_1(x_{ij} - \bar{x}_j) + \beta_2 \bar{x}_j + u_j + e_{ij}.$$

β_1 represents the within effects, which are estimated by group mean centering the variables, and β_2 is the group mean, which represents the between effects. u_j is the Level 2 error term, and e_{ij} is the Level 1 error term.[3] The primary advantage of this model is that it allows the researcher to obtain both the within and between effects simultaneously. Doing so is not possible in the standard fixed-effects model, which relies on within variance only, or the standard random-effects model, which uses a weighted average of within and between variance (Bell, Fairbrother, and Jones 2019). In the context of this study, it allowed us to test whether an increase in a driver within a state had the same effect as cross-sectional differences (the average level of the driver) between states.

Before group mean centering the variables, we grand mean centered all of the independent variables to provide a meaningful interpretation of the intercepts. The dependent variable and independent variables were converted to natural logarithms, making them equivalent to elasticity models. We logged the variables to (1) correct for skewness and (2) because we posited that the relationship between drug-related mortality and its determinants are multiplicative in nature; that is, the determinants are not independent of one another but rather, act proportionally. To correct for autocorrelation, each model was estimated with an exponential covariance structure, which models an autoregressive process (Rabe-Hesketh and Skrondal 2012). We also estimated robust standard errors to correct for heteroskedasticity.

Drug-Related Mortality Rate per 100,000 People

Our dependent variable was the annual drug-related mortality rate per 100,000 people by state. We obtained these data from CDC WONDER's (CDC 2018) multiple cause of death database. As defined by the CDC, drug-related deaths are those that are unintentional (ICD-10 codes X40-X44), by suicide (ICD-10 codes X60-X64), by homicide (ICD-10 code X85), undetermined (ICD-10 codes Y10-Y14), and all other drug-induced causes (deaths not categorized in any of the aforementioned ICD-10 codes).

Key Independent Variables: Educational Attainment, Opioid Prescription Rates, and Income Inequality

Our three main variables of interest were educational attainment (the percentage of the state population with a bachelor's degree), the opioid prescription rate (per 100 people), and four different measures of income inequality: the income share of the (1) top 5%, (2) the top 20%, (3) the bottom 20%, and (4) the Gini coefficient (range = 0–1). Educational attainment (used to test the demand-side hypothesis) and the inequality measures (used to test the income inequality hypothesis) were obtained from the American Community Survey (ACS) 1-year estimates (U.S. Census Bureau 2018a), and the opioid prescription rates (used to test the supply-side hypothesis) were garnered from the CDC (2019).

Each measure of income inequality provided a sufficiently different approach to understanding how inequality is associated with drug-related mortality. The share of income going to the top 5%, top 20%, and bottom 20% are measures of concentration toward the tail ends of the income distribution, whereas the Gini coefficient takes into account the entire income distribution but does not indicate specifically where the inequality lies within the distribution (Burns, Tomita, and Lund 2017; Hill and Jorgenson 2018; Jorgenson, Schor, and Huang 2017). Therefore, the Gini coefficient provided a general measure of how unequal a distribution is, whereas income shares provided more specific measures of how resources are concentrated at specific locations along the income distribution. The income inequality measures were estimated from income data that were calculated as the sum of wages net of all other forms of income, such as government assistance, interest, and dividends (U.S. Census Bureau 2018b).

Additional Covariates

Following the social determinants of health literature (e.g., Monnat 2018; Solar and Irwin 2010), we included additional covariates that controlled for the structure of each state's economy and potential regional differences that could be driving the epidemic. Our models included two trend terms, one that was centered on the year 2006 and a second one that was the quadratic trend term, which we deemed appropriate based on the Bayesian information criterion (BIC) statistic. In addition, we included the annual state-level median household income in 2017 inflation-adjusted dollars and the percentage of the labor force in manufacturing, which controlled for the affluence and structure of the economy for each state, respectively. To control for regional differences, we included a set of indicator variables denoting census region (1 = Northeast, reference group; 2 = Midwest; 3 = South; 4 = West). The median household income data and the percentage of the labor force in manufacturing were gathered from the ACS 1-year estimates (U.S. Census Bureau 2018a). The census regions followed the U.S. Census Bureau's (2015) categorization. We report sensitivity analyses with additional covariates in the Sensitivity Analysis section following the results.

RESULTS

Descriptive Statistics: Where Is the Variance?

The univariate, nonlogged descriptive statistics for the dependent and independent variables are reported in Table 1. The table includes the mean and the overall, within, and between standard deviation (SD) for each variable. For all of the variables, the variance is greater between states rather than within them over time. Particularly notable is the mean of the drug-related mortality rate, which is 15.98 deaths per 100,000 people. The mortality rate varies substantially within states (within SD = 4.80) and between states (between SD = 4.98). Figure 1 illustrates the average drug-related mortality rate from 2006 to 2017, and Figure 2 shows the change in the mortality rate over the same period.

We also found that much of the variance for our three main independent variables of interest (the percentage of the population with a bachelor's degree, the opioid prescription rate, and income inequality) is between states rather than within them. The mean percentage of people with a bachelor's degree is 28.84 (between SD = 5.86%; within SD = 1.63%), and the mean opioid prescription rate is 79.41 opioids per 100 people (between SD = 21.88; within SD = 8.14). Regarding income inequality, the mean share of income going to the top 5% is 21.50% (between SD = 1.37%; within SD = .68%), and the mean Gini coefficient is .46 (between SD = .02; within SD = .01). The average share of income going to the top 20% is 49.37% (between SD = 1.86%; within SD = .70%), whereas the mean share of income going to the bottom 20% is 3.46% (between SD = .41%; within SD = .15%).

Table 1. Descriptive Statistics: CDC Wonder and American Community Survey 1-Year Estimates, 2006 to 2017.

	Measurement	Mean (SD)	Between SD	Within SD	*n*
Drug-related mortality	Per 100,000 people	15.98 (6.89)	4.98	4.80	612
% Bachelor's degree	%	28.84 (6.03)	5.86	1.63	612
Opioid prescription rate	Per 100 people	79.41 (23.16)	21.88	8.14	612
Top 5%	%	21.50 (1.52)	1.37	.68	612
Top 20%	%	49.37 (1.97)	1.86	.70	612
Bottom 20%	%	3.46 (.43)	.41	.15	612
Gini	Index	.46 (.02)	.02	.01	612
Median household income	2017 inflation-adjusted $	59,386.58 (11,563.06)	9,705.46	6,419.06	612
Manufacturing	% of labor force	10.22 (3.98)	3.99	.57	611

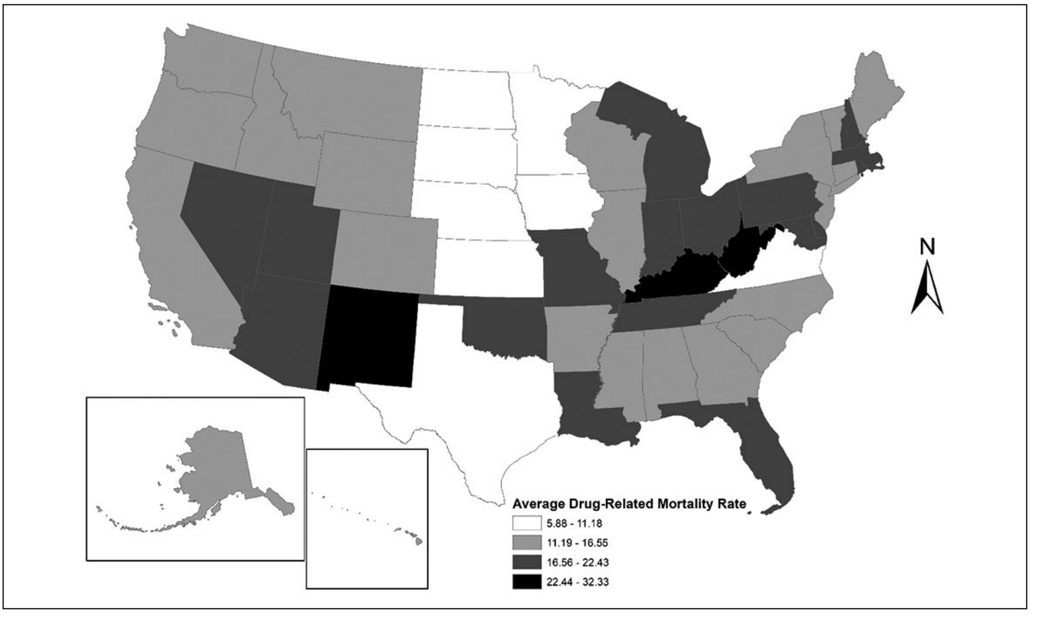

Figure 1. Average Drug-Related Mortality Rate, 2006 to 2017.

Random Intercept Model Results

We first estimated a model that included all of the within and between effects for each independent variable (not reported here) and used Wald tests (Table 2) to determine whether the between and within effects for the continuous variables are statistically different from one another. Of the five continuous independent variables included in the model, only the opioid prescription rate's within and between effects are statistically different at the .05

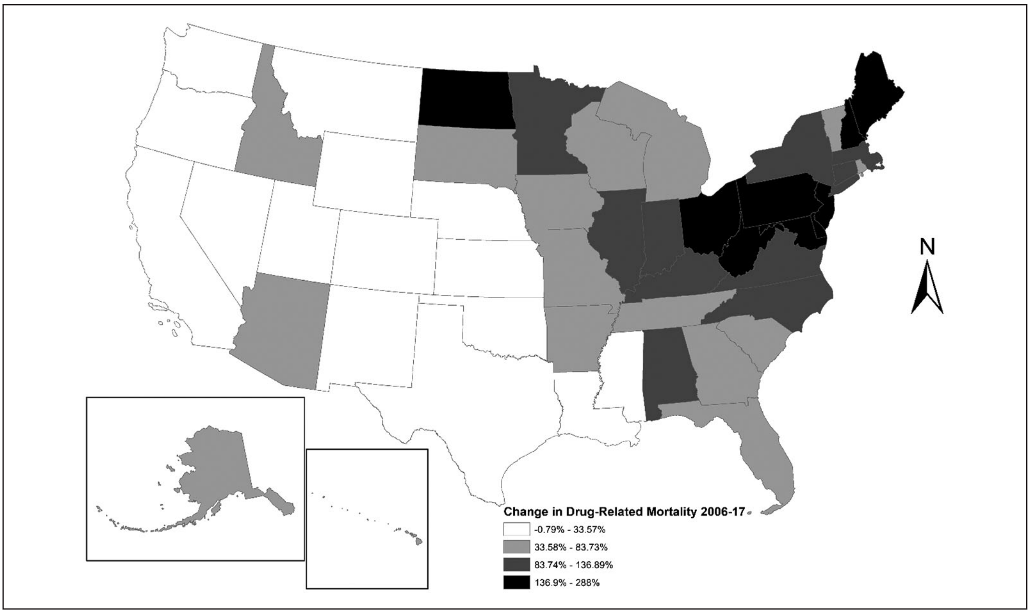

Figure 2. Percentage Change in the Drug-Related Mortality Rate from 2006 to 2017.

Table 2. Wald Tests of the within and between Effects: CDC WONDER and American Community Survey 1-Year Estimates, 2006 to 2017.

	(1) Top 5%	(2) Top 20%	(3) Bottom 20%	(4) Gini
% Bachelor's degree	.19	.03	.05	.02
Opioid prescription rate	22.15*	22.43*	22.66*	22.53*
Income inequality	1.65	2.51	3.24	2.45
Median household income	.50	1.21	1.70	1.30
Manufacturing	.21	.16	.00	.12

Note: The test statistics are χ^2 values.
*$p < .05$. H_0: The coefficients are equivalent.

level. As such, we included the within and between effects for the opioid prescription rate in the models and report the random effects (because they are more efficient than the within effects) for the other variables.

Table 3 reports the results of the two-level random intercept models for drug-related mortality by income inequality measure, and Figure 3 visually presents the point estimates and confidence intervals for each key variable (the percentage of people with a bachelor's degree, the opioid prescription rate, and each inequality measure). All of the two-level intercepts are statistically significant, indicating that the two-level model fits the data well and is superior to the linear model. The percentage of people with a bachelor's degree is not statistically significant at the .05 level in any of the models, which does not support the demand-side hypothesis. The opioid prescription rate's within effects are not statistically significant in any model, but all of the between effects are, which supports the supply-side hypothesis. In other words, states with a higher rate of opioid prescriptions, on average, have a higher drug-related mortality rate.

The results for the income inequality measures indicate that inequality has a complex association with drug-related mortality. In contrast to what the income inequality hypothesis expects, the share of income of the top 5%, the top 20%, and Gini coefficient are not associated with drug-related mortality, but the share of income of the bottom 20% is negatively associated with

Table 3. Two-Level Random Intercept Model for the Regression of the Drug-Related Mortality Rate, 2006 to 2017 (*N* = 611): CDC WONDER and American Community Survey 1-Year Estimates.

	(1) Top 5%	(2) Top 20%	(3) Bottom 20%	(4) Gini
% Bachelor's degree	.49	.49	.50	.49
	(.26)	(.26)	(.26)	(.26)
Opioid prescription rate, within	−.05	−.05	−.04	−.05
	(.16)	(.16)	(.16)	(.16)
Opioid prescription rate, between	1.15*	1.17*	1.23*	1.18*
	(.24)	(.24)	(.24)	(.24)
Income inequality	.18	.89	−.48*	.83
	(.22)	(.63)	(.23)	(.53)
Median household income	.11	.11	.12	.12
	(.07)	(.07)	(.07)	(.07)
Manufacturing	−.27*	−.27*	−.25*	−.27*
	(.11)	(.11)	(.10)	(.11)
Midwest	−.32*	−.30*	−.28*	−.30*
	(.12)	(.12)	(.11)	(.11)
South	−.33*	−.35*	−.36*	−.35*
	(.08)	(.08)	(.08)	(.08)
West	−.25*	−.23*	−.20*	−.22*
	(.10)	(.10)	(.09)	(.10)
Time	−.02	−.02	−.03	−.03
	(.02)	(.02)	(.02)	(.02)
Time^2	.01*	.01*	.01*	.01*
	(.00)	(.00)	(.00)	(.00)
Constant	3.04*	3.05*	3.02*	3.04*
	(.70)	(.69)	(.70)	(.69)
Random components				
State-level intercept	.04*	.04*	.04*	.04*
	(.01)	(.01)	(.01)	(.01)
Year intercept	.05*	.05*	.05*	.05*
	(.01)	(.01)	(.01)	(.01)
Rho	.76*	.76*	.76*	.76*
	(.06)	(.06)	(.06)	(.06)
BIC	−450.18	−452.51	−457.66	−453.18

Note: Robust standard errors are in parentheses. The models are estimated with an exponential covariance structure to correct for autocorrelation. Census region reference group = Northeast. BIC = Bayesian information criterion.
*$p < .05$.

drug-related mortality. Moreover, the values of the BIC statistic for each model indicate that the bottom 20% model best fits the data. Based on Raftery's (1995) grades of evidence,[4] there is "strong" evidence that the bottom 20% model is better than the top 5% model and "positive" evidence that it is better than the top 20% model and the Gini model. Overall, these results indicate that the lack of resources going to the bottom 20% of earners best explains the income inequality–drug-related mortality relationship—rather than the concentration of resources at the top of the income distribution.

Sensitivity Analysis

As a sensitivity analysis, we estimated models with two additional covariates that may be associated with the drug epidemic (Ariizumi and Schirle 2012; Case and Deaton 2015; Ruhm 2005): (1) the percentage of the population that is white and (2) a dichotomous variable corresponding to the years of

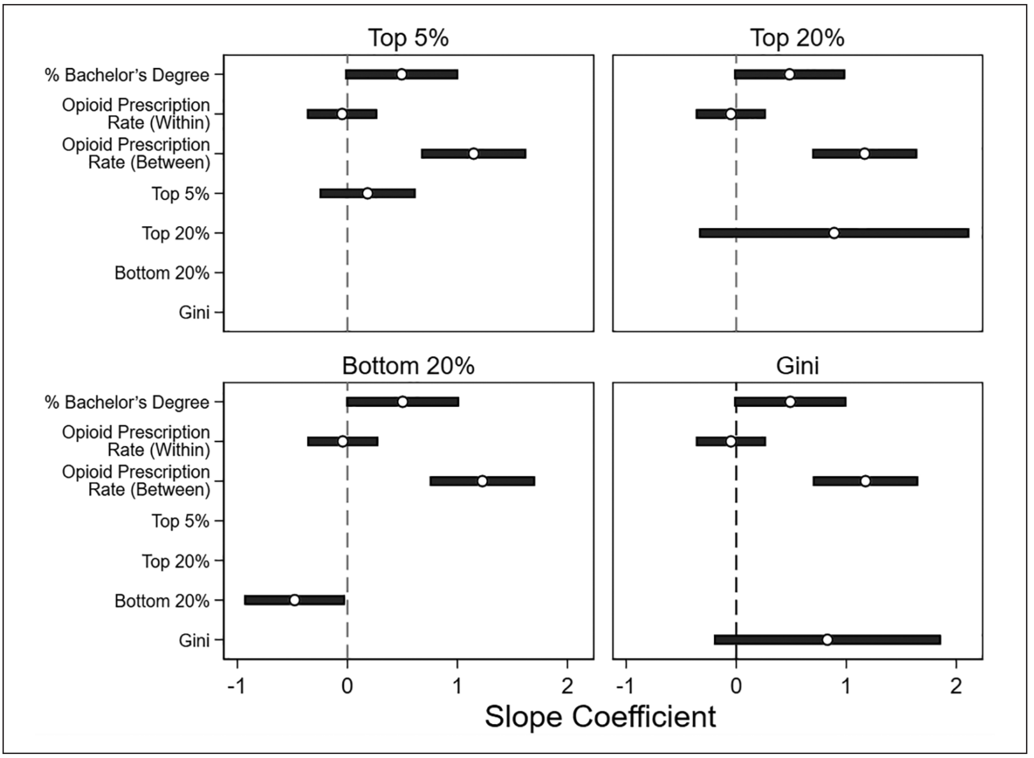

Figure 3. Key Results by Income Inequality Model.
Note: The circle represents the point estimate, and the black bars correspond to the 95% confidence interval.

the Great Recession (1 = the years 2008 and 2009; 0 = otherwise). Measures of the percentage of the population that is white were obtained from the ACS 1-year estimates (U.S. Census Bureau 2018a), and the recessionary years were coded according to the National Bureau of Economic Research (2010).[5] The results are reported in Appendix A available in the online version of the article.

The inclusion of the additional variables makes the bottom 20% slope coefficient only marginally statistically significant (p = .06). However, neither the percentage of the population that is white nor the Great Recession dichotomous variable are statistically significant in the models. Additionally, the model's BIC values are significantly larger than the ones reported in the aforementioned results. The difference between the BIC value for the bottom 20% model in the main results compared to the sensitivity analysis is 11.19, indicating "very strong" evidence that the main results fit the data better than the sensitivity analysis. Overall, these findings suggest that the inclusion of the additional variables is unwarranted and that their addition leads to inflated standard errors.

At a reviewer's request, we also interacted the Great Recession variable with our main variables of interest—the percentage of people with a bachelor's degree, the opioid prescription rate (between effect), and each inequality measure. The results are reported in the Appendix B available in the online version of the article. The interaction is not statistically significant for the percentage of people with a bachelor's degree or the opioid prescription rate, but it is for all of the inequality measures except for the share of the top 5%.[6] The results suggest that none of the inequality measures had an effect on drug-related mortality during the Great Recession but did so during nonrecessionary years. The slope coefficient of the top 20% during the Great Recession was –.28 (p = .77), compared to its nonrecession slope coefficient of 1.13 (p = .04). The slope coefficient of the bottom 20% during the Great Recession was –.08 (p = .74), compared to its nonrecession slope coefficient of –.58 (p = .02), and the Gini's Great Recession slope coefficient was –.10 (p = .75), compared to its nonrecession slope coefficient of 1.06 (p = .46). These findings align with prior research showing that some population health characteristics improve during recessionary periods (Ariizumi and Schirle 2012; Ruhm 2000, 2005). Regardless, the primary results reported in this study appear to be more robust compared to alternative specifications and both opioid prescription rates and the income share of the bottom 20% of earners are drivers of the drug overdose epidemic.

DISCUSSION

The results of this study have important implications for understanding the drivers of the U.S. drug overdose epidemic and the policies needed to combat it. Regarding the drivers of drug-related mortality, the findings support the arguments made by the supply-side perspective more so than the demand-side perspective. As we discussed, the supply-side perspective argues that changes in the drug environment are driving the epidemic. For the licit drug market, prior research points to the exploitive practices of pharmaceutical companies that made opioids more available to the general public (Ruhm 2019). Even though the prescribing rates of licit opioids have declined during the past several years, the illicit drug market has picked up where it left off by making fentanyl and heroin increasingly cheap and widely available. Undoubtedly, the increase in cheap opioids (and other drugs) plays a significant role in the epidemic.

However, the arguments made by the supply-side approach have limited explanatory power when it comes to the underlying mechanism of why the epidemic emerged. For example, the supply-side argument does not provide an explanation for what is driving people to use drugs, and it does not offer a compelling reason for why the epidemic is disproportionately affecting white (and increasingly black) working-class people without a college degree (Case and Deaton 2020). Although the demand side's emphasis on educational attainment is not supported in this study, we contend that income inequality can act as a link between the arguments made by the demand-side and the supply-side approaches. On one hand, increasing inequality both produces and is reproduced by the health care and pharmaceutical industries at the center of the epidemic. Americans are reporting higher levels of pain than ever before, but the reported increase appears to be largely from social and economic distress rather than from physical ailments (Case and Deaton 2020). Beginning in the 1990s, the pharmaceutical industry quickly "pharmaceuticalized" this phenomenon by treating it as a medical issue to be addressed by pharmaceuticals and drugs rather than by policy interventions or social change (Abraham 2010; Bell and Figert 2012). On the other hand, income inequality is also an important demand-side factor because it concentrates resources and power among a small number of elites, which increases alienation and undermines the well-being of lower income groups (Neumayer and Plümper 2015; Wilkinson and Pickett 2019). As we show, the best inequality predictor of drug-related mortality is the lack of resources going to the poorest 20% of earners relative to everyone else.

Building on this discussion, the results indicate that health policy should take on a wider set of measures to combat the drug overdose epidemic. The actions taken by federal and state governments in the United States have primarily focused on the practices of pharmaceutical companies and prescribing physicians (Gross and Gordon 2019). Although we find that addressing the supply side of the epidemic is necessary—it is an inadequate prevention response by itself (also see Monnat 2019; Peters et al. 2019). Policymakers must also address structural factors like economic inequality, which will require implementing policies that redistribute income and resources. Although wealth is not explicitly discussed in this article, implementing a wealth tax may be an even more effective strategy because the wealthiest often structure their assets so they have relatively low levels of taxable income (Saez and Zucman 2019). Furthermore, eliminating private insurance and moving to a single-payer system could potentially not only check the power of pharmaceutical companies and limit the harmful prescribing practices of physicians but also serve as a large pay increase for employees. Today, an employee's health care costs an average of $13,000 a year, and a single-payer system funded through progressive taxation would shift the burden of paying for health care from workers to the rich (Saez and Zucman 2019).

Although the findings for this study are relatively robust, they should be interpreted with two limitations in mind. First, due to the availability of opioid prescription rates, our analysis dates back to 2006. However, as Case and Deaton (2015) showed, drug-related mortality has been on the rise since the beginning of the twenty-first century. This longer-term trend is not captured in the present study. Second, there may also be important spatial differences within states, such as at the county or city levels, that are not captured in this state-level study. Future research should evaluate whether this is the case.

We conclude by reiterating that drug-related mortality is likely a deleterious "downstream" consequence of changes in the U.S. economy over the past half-century that have led to increased income inequality and an exploitive private health care and pharmaceutical industry. Our emphasis on the role of income inequality in the current drug overdose epidemic is consistent with recent research demonstrating that growing income inequality is a key determinant of other health-related outcomes, including overall life expectancy, crime, and mental illness as well as anthropogenic greenhouse gas emissions that cause climate change and exacerbate air pollution's impact on public health (Hill, Jorgenson et al. 2019; Hill and Jorgenson 2018; Jorgenson et al. 2016, 2017, 2020; Knight, Schor, and Jorgenson 2017; Pickett and Wilkinson 2015). Therefore, addressing the supply side of the drug overdose epidemic is certainly warranted, but taking a more structural perspective to the epidemic that involves reducing income inequality would likely not only lead to reduced drug-related mortality but also have positive economic and environmental benefits.

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NOTES

1. Case and Deaton's emphasis on education aligns with sociological work that explains why education is important to health (e.g., Mirowsky and Ross 2015). In the postindustrial economy, educational attainment is critical to accessing well-paying jobs (Case and Deaton 2020). Mirowsky and Ross (2015:297) also argued that education is important for individuals to be able to overcome the unhealthy "default American lifestyle."
2. Some researchers refer to it as the *hybrid model*, but this term is misleading because it is a random-effects model—not a combination of the fixed-effects and random-effects models (Bell and Jones 2015).
3. Although the within effects are not subject to constant, time-invariant unobserved heterogeneity bias, the between effects can be biased if time-invariant (Level 2) variables are omitted from the model. However, the within effects are still subject to time-variant omitted variable bias (also see Hill, Davis, et al. 2019).
4. Raftery's (1995) grades of evidence provide a way to compare how well different, nonnested models fit the data.
5. Technically, the Great Recession began in December 2007, but we code 2007 as a 0 because it is the last month of the year.
6. The percentage of the population that is white is excluded because the BIC values of the models are significantly smaller when it is removed from the analysis, and it is not statistically significant in any of the analyses.

SUPPLEMENTAL MATERIAL

Appendices A and B are available in the online version of the article.

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