The Drug Overdose Death Epidemic: Evidence from U.S. Counties

Tomi Ovaska
Professor of Economics
Youngstown State University
One University Plaza
Youngstown, OH 44555, USA
tpovaska@ysu.edu
+1-(330)- 941-3428

Albert Sumell
Professor of Economics
Youngstown State University
One University Plaza
Youngstown, OH 44555, USA
ajsumell@ysu.edu
+1-(330)- 941-3428

Yogesh Uppal
Professor of Economics
Youngstown State University
One University Plaza
Youngstown, OH 44555, USA
yuppal@ysu.edu
+1-(330)- 941-3428

Abstract

The number of Americans who died from drug overdose deaths has more than quadrupled in the past two decades, reaching an all-time high in 2021. Although research has shown a strong connection between drug abuse and mental or physical health, this relationship has not yet been explored at the county level. Using a unique panel data for all U.S. counties in 2012-17, this study evaluates the importance of self-perceived physical and mental health, as well as diverse income and socio-demographic factors in contributing to rising drug overdose death rates. Our findings suggest that mental and physical distress are important indicators of drug overdose deaths. Furthermore, the effect of mental and physical distress on overdose deaths is larger in urban than in rural counties. These results imply that to effectively combat the drug epidemic, policymakers and community health advocates should prioritize improved and more accessible mental and physical health care to their residents.

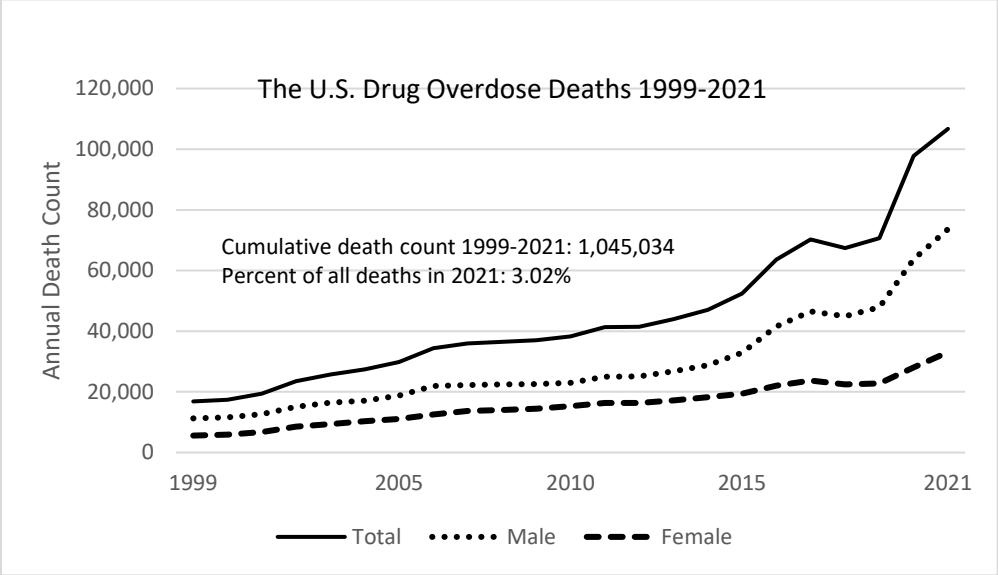
JEL Codes: C23: D01; D91; I12; I14; I18; I31; J17; P37

Keywords: Drug overdose deaths; Epidemic; Factors explaining drug overdose deaths; Opioids; Overdose, Panel data; Rise in drug overdose deaths; Synthetic drugs; U.S. counties; Years 2012-17

1. Background

The United States is amid a drug overdose epidemic that has impacted practically every community across the nation. Centers for Disease Control and Prevention (CDC) data show that over 106,000 Americans died from a drug-involved overdose in 2021, as compared to fewer than 17,000 in 1999. *Figure 1* shows the time trend of drug overdose deaths, split by sex.[1] Over the last two decades, over one million Americans have died of a drug overdose. If the current growth trend continues, drug overdose would become the third most common cause of death in America by the end of this decade, trailing only heart disease and cancer.

Figure 1: Drug Overdose Deaths Over Time



Source: NCHS Data Brief No. 394 (December 2020), NCHS Vital Statistics Rapid Release (August 2021), National Institute on Drug Abuse (February 2023)

This paper examines how self-perceived mental and physical distress relates with both actual and estimated drug overdose death rates in a panel of 3,136 U.S. counties or Census

[1] Source: Estimated from the International Classification of Diseases, Tenth Revision Data: https://icd10cmtool.cdc.gov/

equivalent entities over the period 2012-17.[2] Opioid usage in the U.S. started a steady climb in the late 1990's as opioids became more widely prescribed to treat chronic pain (Keefe, 2021).[3] This spawned an increase in misuse, dependency, and overdose deaths, which have been exacerbated by the wide availability and low cost of illegal new generation synthetic opioids in recent years.[4] The above problems are compounded by mental health issues. Davis et al. (2017) note that just 16% of the 39 million Americans with mental health disorders account for more than half of all opioid prescriptions. Further, the 2017 National Survey on Drug Use and Health (*NSDUH*) found that approximately 43% of Americans with a substance abuse disorder also suffered from a mental health disorder, and that about 60% of people who misused pain relievers did so in order to relieve physical pain (NSDUH, 2018). This suggests that mental and physical distress are important contributors to the current drug overdose epidemic.

To get a sense of the societal costs of the drug overdose epidemic one can use the U.S. Environmental Protection Agency's value of a statistical life estimate: $9.7 million per life in 2020 dollars. Multiplying that value with 2021 drug overdose deaths yields $1.035 trillion as the estimated cost of drug overdose deaths in the U.S. This cost is equivalent to about 4.2% of the U.S. GDP in 2021. Overdose death statistics alone, however, show only one part of the toll

[2] The dataset includes 3,006 counties, 14 boroughs and 11 census areas in Alaska; the District of Columbia; 64 parishes in Louisiana; Baltimore City, Maryland; St. Louis city, Missouri; Carson City, Nevada; and 41 independent cities in Virginia.

[3] According to CDC's WONDER-database, opioids, such as tramadol, morphine, codeine, oxycodone, heroin, methadone, fentanyl, and carfentanil are involved in 71% of all drug overdose deaths, though the exact cause of death is frequently a combination of two or more drugs (e.g., opioids, cocaine, psychostimulants, benzodiazepines and antidepressants). From the CDC data one can identify three distinct drug overdose death waves since the 1990s. The first wave started with the unprecedented rise in use of oxycodone, which is about twice as potent as morphine. The second wave around 2007 saw a dramatic rise in the consumption of even more potent semi-synthetic opioids, in particular heroin. The third wave started around 2013 with the introduction of the synthetic fentanyl and then carfentanil, the latter up to 10,000 times more potent than morphine.

[4] According to the NCHS DB-394 publication synthetic opioids (excluding methadone) cause already more overdose deaths as natural and semi-synthetic opioids together.

of the U.S. drug crisis; approximately 19 million of Americans struggle with a substance abuse disorder (NSDUH, 2018). Overstretched healthcare and judicial systems, forlorn education, and lost workplace productivity all add significant economic costs. Luo et al. (2021) estimate the non-death economic costs of opioids at $1.021 trillion in 2017, equal to more than 5% of the U.S. GDP.

2. Data and Empirical Methodology

This study examines the relationship between self-perceived physical and mental health, and economic and socio-demographic variables on drug overdose deaths in all 3,136 U.S. counties and their equivalent entities from 2012 to 2017. The source of drug overdose deaths data is from the *National Center for Health Statistics (NCHS)*, *Centers for Disease Control and Prevention (CDC)*. Actual drug overdose death counts are reported in the CDC Wonder database for all U.S. counties with ten or more annual overdose deaths. [5] For counties with fewer than ten overdose deaths in a year, the empirical model uses estimated drug overdose death rates from the National Vital Statistics System *(NVSS)*. [6] All other county data are from *The University of Wisconsin Population Health Institute*, *County Health Rankings and Roadmaps*.[7]

[5] Centers for Disease Control and Prevention. CDC Wonder, (http://wonder.cdc.gov/NCHS)

[6] National Vital Statistics System, mortality data (http://www.cdc.gov/nchs/deaths.htm). According to the NCHS, "Deaths are classified using the International Classification of Diseases, Tenth Revision (ICD–10). Drug overdose deaths are defined as having ICD–10 underlying cause-of-death codes X40–X44 (unintentional), X60–X64 (suicide), X85 (homicide), or Y10–Y14 (undetermined intent). … County-level estimates were generated using Hierarchical Bayesian models with spatial and temporal random effects using the INLA package for R (3–5). These models borrow strength over time and across neighboring counties to produce stable estimates of drug overdose death rates by county and year." (see: http://www.cdc.gov/nchs/deaths.htm)

[7] The University of Wisconsin Population Health Institute. County Health Rankings & Roadmaps, 2020. www.countyhealthrankings.org

Mental health is measured by the average number of self-perceived mentally unhealthy days reported by adults in a representative survey of residents in the past 30 days (*Mentally unhealthy days*) and by the percentage of adults reporting 14 or more days of poor mental health per month (*Percent frequently distressed*).[8] Physical health is measured by the average number of physically unhealthy days reported by adults in the past 30 days (*Physically unhealthy days*) and by the percentage of adults who consider themselves to be in fair or poor health (*Percent fair or poor health*).[9] Since there is a substantial overlap in an individual's perception of physical and mental distress, these variables may be considered an indirect measure of well-being in counties.

The empirical model used is:

$$Log(DEATHRATE_{cst}) = \beta 0 + \lambda_c + \delta_t + \beta 1 * HEALTH_{cst} + \beta 2 * X_{cst} + \beta 3 * Z_{ct} + \beta 5 * \theta_s * trend + \varepsilon_{cst} \quad (1)$$

where $DEATHRATE_{cst}$ refers to drug overdose deaths per 100,000 residents in county *c* in state *s* in year *t*, $HEALTH_{cst}$ represents mental or physical health measures in county *c* in state *s* in year *t*.

The vector X_{cst} represents county economic variables including per capita income, income inequality as measured by the ratio of the 80th and the 20th percentile income groups, unemployment rate, and percent of working age adults without health insurance. The vector

[8] Mental health measures are based on adult responses to the *Behavioral Risk Factor Surveillance System* question that is phrased as: "Now, thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?".
[9] Physical health measures are based on adult responses to two *Behavioral Risk Factor Surveillance System* questions: "In general, would you say that in general your health is Fair or Poor?" and "Thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?".

Z_{cst} includes socio-demographic control variables at the county level: population, percent white, percent female, percent aged 17 years and under, percent aged 65 years and over, percent with some college, and percentage of adult population that smokes. The vector λ_c represents a fixed effect unique to county *c* that controls for county-level time-invariant factors, such as location or climate that may affect overdose death rates. As *Figure 1* suggests there is a consistent upward trend in drug overdose deaths over time, we include year fixed effect (δ_t) that control for common trends across all counties. We also include a state-specific linear time trend (θ_s**trend*) to account for state-specific policy changes over time. Finally, ε_{cst} is the error term.

Since our unit of observation a county c (in year t), our data represents county level averages. The model in equation (1) would give equal weights to all counties irrespective of their populations. As a correction, we also report regression results using the square root of county population as the weight.[10] Since the drug overdose death rate is likely to be correlated over time within each county, we cluster standard errors at the county level. *Table 1* provides data definitions and summary statistics.

Table 1. Summary Statistics

Variable	Definition	N	Mean	Std Dev	Min	Max
Death Rate/100,000	Number of drug overdose deaths per 100,000 county residents	18825	17.5	9.05	2.23	152.7
Mentally unhealthy days	Average number of mentally unhealthy days over the past 30 days self-reported by adults	17723	3.79	0.78	1	10.1

[10] We thank two anonymous referees for this suggestion.

Percent frequently distressed	% of adults reporting 14 or more days of poor mental health in the last month	18823	11.8	2.1	6.6	21.3
Physically unhealthy days	Average number of physically unhealthy days in the past 30 days self-reported by adults	18159	3.88	0.88	1.1	10
Percent fair or poor health	% of adults who self-report to be in fair or poor health	18027	17.3	5.25	4.4	50.8
Percent smokers	% of adults who smoke	17967	18.9	4.87	3.1	51.1
Per capita income	Per capita income (hundreds, 2010$)	18552	400.8	113.9	115.4	2261.3
Income spread	80th percentile household income minus 20th percentile household income (hundreds)	18821	4.51	0.72	2.56	10.7
Unemployment rate	County unemployment rate	18819	6.1	2.49	0.82	28.3
Percent uninsured	% of population without health insurance	18824	14	5.85	2.07	41.6
Percent some college	% of adults with some postsecondary education	18825	56.5	11.7	2.56	100
Population	Number of county residents (hundreds)	18804	99630	285304	86	9956152
Percent female	% of population who identify as female	18825	49.9	2.26	26.6	57
Percent white	% of population who identify as Caucasian	18825	77.1	19.9	2.76	98.9
Percent age ≥ 17	% of population age 17 or under	18825	22.5	3.42	0	42.2
Percentage ≥ 65	% of population age 65 or older	18825	17.8	4.52	3.61	56.9

3. Results

Table 2 reports results from Equation (1). The specifications differ according to which measure of mental or physical health is included. Specifications (1) - (4) include measures of county mental health, while specifications (5) – (8) include measures of county physical health. The coefficients on one mental and two physical health variables are positive and statistically and economically significant. The coefficients are similar irrespective whether we use equal weights or not. The results suggest that a one percentage point increase in the percent of

mentally unhealthy days is associated between 1.00% to 1.38% increase in overdose death rate. Based on our summary statistics and regression estimates, an increase from 17.5% to 18.5% of mentally unhealthy days is associated with between 580 and 800 additional overdose deaths per year. The other mental health measure, percent frequently distressed, is not statistically significant.

Both coefficients on physical health measures are positive and economically significant. An additional physically unhealthy day is associated with a 1.15% to 1.56% increase in overdose death rate. A one percentage point improvement in physical health is associated about between 580 to 800 fewer overdose deaths. Equally, halving of the number of people in fair or poor health is associated with about between 1,100 and 1,900 lives saved a year. Like most previous studies, we find no effect of income (Ruhm 2019, Rees et al. 2019, Erfanian et al. 2019) on overdose deaths. Income inequality, as measured by log of income ratio, is also statistically insignificant. Demographic variables, an increasing share of whites, minors, and seniors, is associated with a higher death count. As previous studies, we find no connection

Table 2: Estimation Results U.S. Counties: Dependent variable = Log Overdose Death Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mentally unhealthy days	0.0100**	0.0138**						
	[0.0040]	[0.0058]						
Percent frequently distressed			-0.0021	-0.00643				
			[0.0038]	[0.0057]				
Physically unhealthy days					0.0115***	0.0156***		
					[0.0033]	[0.0052]		
Percent fair or poor health							0.00227***	0.00378***
							[0.0007]	[0.0011]
Log (population)	0.00394	0.00861	0.00501	0.00945	0.00543	0.01	0.00453	0.00874
	[0.0081]	[0.0119]	[0.0081]	[0.0120]	[0.0081]	[0.0120]	[0.0081]	[0.0120]
Log (per capita	-0.00997	0.0806	-0.0112	0.07	-0.01	0.0759	-0.0101	0.0744

income)	[0.0266]	[0.0608]	[0.0251]	[0.0584]	[0.0256]	[0.0595]	[0.0259]	[0.0597]
Log (income ratio)	0.0122	0.0337	0.013	0.0438	0.0114	0.0366	0.00862	0.0312
	[0.0215]	[0.0442]	[0.0210]	[0.0433]	[0.0211]	[0.0436]	[0.0213]	[0.0439]
Unemployment rate	-0.00132	0.00399	-0.0008	0.00445	-0.00117	0.0039	-0.00073	0.00445
	[0.0022]	[0.0032]	[0.0021]	[0.0031]	[0.0021]	[0.0031]	[0.0021]	[0.0031]
Percent female	-0.00325	-0.00718	-0.0026	-0.00595	-0.00321	-0.00722*	-0.00284	-0.00698
	[0.0026]	[0.0044]	[0.0025]	[0.0043]	[0.0026]	[0.0043]	[0.0026]	[0.0043]
Percent uninsured	-0.00014	-0.00321	1.09E-05	-0.00264	-0.000108	-0.00304	-0.000214	-0.00324
	[0.0012]	[0.0020]	[0.0012]	[0.0020]	[0.0012]	[0.0020]	[0.0012]	[0.0020]
Percent some college	-0.00022	0.000379	-0.0003	8.26E-05	-0.000179	0.000413	-0.000186	0.000479
	[0.0006]	[0.0009]	[0.0006]	[0.0009]	[0.0006]	[0.0009]	[0.0006]	[0.0009]
Percent smokers	-0.0009	0.000118	-0.0005	0.000592	-0.00124**	-0.000333	-0.00141**	-0.000841
	[0.0006]	[0.0010]	[0.0005]	[0.0009]	[0.0006]	[0.0010]	[0.0006]	[0.0010]
Percent white	0.000765	0.00152**	0.00073	0.00150**	0.000763	0.00152**	0.000860*	0.00167**
	[0.0005]	[0.0007]	[0.0005]	[0.0007]	[0.0005]	[0.0007]	[0.0005]	[0.0007]
Percent minors	0.00333	0.00797*	0.00359	0.00800*	0.00378	0.00852**	0.00337	0.00819*
	[0.0025]	[0.0043]	[0.0026]	[0.0043]	[0.0026]	[0.0043]	[0.0025]	[0.0043]
Percent seniors	0.00361**	0.00407	0.00363**	0.0041	0.00377**	0.00436	0.00342**	0.0041
	[0.0018]	[0.0030]	[0.0017]	[0.0030]	[0.0017]	[0.0030]	[0.0017]	[0.0030]
Observations	17,288	17,288	17,688	17,688	17,542	17,542	17,490	17,490
R-squared	0.506	0.508	0.513	0.51	0.51	0.509	0.509	0.509
Weighted regression	No	Yes	No	Yes	No	Yes	No	Yes

The dependent variable in each column is the log of drug overuse death rate defined as the number of deaths per 100,000 people. The weighted regressions use the square root of the county population as weights. Each regression includes county fixed effects, year fixed effects and state-specific time trend. Standard errors are clustered at the county level and given in parentheses. The symbols ***, **, and * show indicate statistical significance at the 1%, 5% and 10% respectively.

between postgraduate education and drug overdose deaths (Dow et al. 2020, Erfanian et al. 2019, Rees et al. 2019).

Table 3: Rural vs Urban Comparison. Dependent variable = Log Overdose Death Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mentally unhealthy days	0.0172***	0.0230***						
	[0.0060]	[0.0070]						
Percent frequently distressed			0.00635*	0.0032				
			[0.0038]	[0.0048]				
Physically unhealthy days					0.00819	0.0200***		
					[0.0068]	[0.0077]		
Percent fair or poor health							0.00307**	0.00582***
							[0.0013]	[0.0016]
Mentally unhealthy days x Rural	-0.0156**	-0.0251***						
	[0.0062]	[0.0073]						
Percent frequently distressed x Rural			-0.00786**	-0.0113***				
			[0.0037]	[0.0042]				
Physically unhealthy days x Rural					-0.0036	-0.0161**		
					[0.0070]	[0.0080]		
Percent fair or poor health x Rural							-0.0019	-0.00452***
							[0.0014]	[0.0016]
Observations	17,288	17,288	17,688	17,688	17,542	17,542	17,490	17,490
R-squared	0.717	0.687	0.722	0.688	0.72	0.687	0.72	0.688
Weighted regression	No	Yes	No	Yes	No	Yes	No	Yes

The dependent variable in each column is the log of drug overuse death rate defined as the number of deaths per 100,000 people. All regressions include control variables as in Table 2. The weighted regressions use the square root of the county population as weights. Each regression includes county fixed effects, year fixed effects and state-specific time trend. Standard errors are clustered at the county level and given in parentheses. The symbols ***, **, and * indicate statistical significance at the 1%, 5% and 10% respectively.

To examine if there are any rural-urban differences in the relationship between mental or physical health and drug overdose deaths, we interact a dummy that is 1 for rural counties and 0 for urban counties and with the county health variables. We use the census classification of counties into different categories and define counties that are non-core or are labeled a micropolitan statistical area as rural. The results are reported in Table 3. Mental and physical health variables have smaller effects on drug overdose deaths in rural counties compared to urban counties. While the mechanism is unclear, the rural-urban differences may stem from

a higher availability of illicit drugs in metropolitan areas (Center for Behavioral Health Statistics and Quality, 2020) or higher levels of social connectedness in rural areas (Henning-Smith et al. 2018).

4. Conclusion

This paper examines the relationship between self-reported health measures and drug overdose death rate in a large panel of U.S. counties. We find that measures of mental and physical distress have a positive and significant relationship with drug overdose deaths. Both self-reported mental and physical health in counties have a significant relationship with county-level drug overdose death rates. We also find that health measures are less associated with drug overdose deaths in rural than urban counties. Some demographic factors, notably rises in the share of whites, minors, and seniors, are associated with an increasing drug overdose death rate.

While we cannot establish causal relationship, the results provide clear evidence for policymakers to increase funding for local community health programs and organizations as part of the drug prevention and mitigation strategy. Some specific measures include more funding for research into less harmful drugs to treat chronic pain, stronger prescription drug monitoring systems, increasing awareness on the risks of drug misuse, and improving access to drug rehabilitation services.

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