Prevalence and predictors of substance use as a factor in suicide in the USA, 2015–2020: a repeated cross-sectional analysis

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ABSTRACT

Background US rates of substance abuse and suicide mortality increased dramatically in recent years, but little is known about how rising rates of drug and alcohol use are associated with suicide. This study explores the role of substance use in suicide between 2015 and 2020 and identifies individual and geographical factors associated with these patterns.

Methods Repeated cross-sectional data on 103 817 suicide decedents drawn from the 2015–2020 National Violent Death Reporting System, combined with Census geographical data, are examined. Available toxicology reports are investigated to identify shifts in substances involved in suicide. A mixed effects logistic model is applied to identify factors associated with the probability of substance use as a precipitating circumstance for suicide.

Results Close to one in five suicide decedents had a substance-related circumstance. Relative to 2015, the probability of drug or alcohol problems surrounding suicide is higher in subsequent years (eg, in 2020, the probability is 2.6% and 2.5% higher, respectively). The detection of alcohol, the substance most identified in toxicology reports, remained stable over the period. Positive tests for prescription opioids and benzodiazepines declined while those for illicit opioids, marijuana and amphetamines increased. The probability of a drug abuse suicide circumstance is higher among white (Average Marginal Effect (AME) =0.038) and male (AME=0.006) decedents, and lower among those with a college degree (AME=−0.099) and who are foreign-born (AME=−0.078). For alcohol-related suicide circumstances, the corresponding AMEs are 0.033 (white), 0.055 (male), −0.045 (college degree) and −0.035 (foreign-born). After adjusting for individual characteristics, county median household income is associated with a reduced probability of drug abuse circumstances but a higher probability of alcohol problems. Unmet need for treatment at the state level is associated with a higher probability of alcohol-related suicide (AME=0.022).

Conclusions Findings suggest shifts in the substances linked to suicide and reveal the importance of a place's social structure in shaping the substance use-suicide nexus.

INTRODUCTION

The overall suicide mortality rate increased by 37%, from 10.4 per 100 000 to 14.2 per 100 000, between 2000 and 2018 in the USA,[1]

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Substance use is an important risk factor for suicide, but we do not know how recent shifts in substance usage patterns may be associated with suicide, nor have studies adopted a multilevel approach to examine the nexus between substance use and suicide.

WHAT THIS STUDY ADDS

⇒ Close to one in five suicide decedents had a substance use problem as a circumstance precipitating their suicide, and the odds of such a circumstance increased in 2016–2020 relative to 2015.

⇒ Toxicology reports reveal a decline in the prevalence of prescription opioids and an increase in the prevalence of marijuana and illicit opioids found in suicide decedents, shifts that align with changes in drug regulations (eg, prescription management programmes for opioids and increasing legalisation of marijuana) in the USA.

⇒ Beyond individual characteristics, the social structure of places—economic and demographic composition and availability of treatment—is associated with the likelihood that a substance use circumstance underlies a suicide death.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The scourge of substance abuse affects Americans' health in multiplicative ways, suggesting that approaches to address substance abuse (eg, reducing unmet need for substance abuse treatment) may have spillover effects for suicide prevention.

while that from alcohol-induced causes rose 28% over the same general period (1999–2015).[2] The increase in mortality from drug overdoses has been especially pronounced, increasing almost threefold (287%) between 2000 and 2019, in large part driven by the opioid epidemic.[3] These trends represent the constellation of so-called deaths of despair that have disproportionately afflicted middle-aged white Americans without a college degree.[4] The dramatic increase in mortality from these causes (suicide, alcohol and drugs) during young adulthood and midlife for all racial

groups contributed to a slowdown in the long-term rate of increase in life expectancy and produced a decline in the US life expectancy between 2014 and 2017.[5]

These causes of death are closely intertwined. Substance (both drug and alcohol) abuse is widely recognised as an important risk factor for suicidal behaviour because such abuse is both a symptom and a cause of depression and other psychiatric disorders, themselves leading contributors to suicide.[6] A study examining the association of substance use disorders with suicide mortality in a general US population found that suicide risk increased by as much as elevenfold for individuals with multiple alcohol, drug and tobacco disorders.[7] Substances also provide a mechanism for dying by suicide and reduce inhibitions, which can cause people to act impulsively and trigger self-harm.[8] Finally, substance abuse often produces problems with social and work relationships that can further contribute to suicidal behaviour.[9] In a comparison of suicide decedents with diagnoses of substance disorders and mood/anxiety disorders, those with substance problems were more likely to face a wider range of interpersonal stressors (eg, conflicts and breakups) than those with a mood disorder.[10]

Self-harm behaviours (suicide and substance abuse) tend to co-occur with certain individual and contextual attributes.[11] For example, American men with lower levels of education are more likely to die by suicide[12]; they are also more likely to have substance disorders, although the gender differential in substance abuse has narrowed in recent years.[13] Despite the seemingly individualistic nature of self-harm, these deaths vary with structural context across time and place. With respect to suicide mortality, rates tend to be greater in places and periods when unemployment and divorce are high and religiosity, population density and access to means are low.[14–16] Drug-related mortality is more prevalent in counties that are economically disadvantaged and exhibit high levels of family instability, have fewer religious establishments and in-migrants, among other factors.[17 18] Geographical location affects alcohol use through various pathways.[19] The policy context also matters—for example, generous social welfare policies are linked to lower suicide rates,[20] and more treatment options are associated with lower drug overdose rates.[21]

We know less about the potential linkages among these types of death and the relationship between rising substance abuse and suicide rates in recent years. Most prior work typically examines the predictors of substance use and suicide separately rather than the connection between the two. No study, to my knowledge, has adopted a multilevel approach that considers the combined associations of individual and contextual factors with the substance use-suicide nexus. Moreover, regulations surrounding particular drugs have changed—for example, new Centers for Disease Control and Prevention (CDC) guidelines were released in 2015–2016 on prescribing opioids for chronic pain in outpatient settings, along with coprescribing opioids and benzodiazepines,[22] and the legalisation of marijuana has become more widespread.[23] National estimates of overdose rates from particular substances further suggest a shift,[24] with an increase in deaths from synthetic opioids and psychostimulants such as amphetamines.[25] Yet, we do not know whether or how these changes may be implicated in suicide.

The present study examines the role of drugs and alcohol in suicide deaths from 2015 to 2020 using data from the National Violent Death Reporting System (NVDRS) to address the following research questions:

1. What substances are typically identified in the available toxicology reports of suicide decedents and has the prevalence of those substances changed between 2015 and 2020?
2. Using data on NVDRS coded circumstances, what individual, county and state-level factors are associated with the likelihood of a drug abuse or alcohol-related circumstance surrounding a suicide?

METHODS
Data come from the NVDRS, an incident-based violent death surveillance system established by the CDC in 2003 to assist states and local communities in violence prevention efforts. Information is collated from medical examiner and coroner reports, toxicology reports, law enforcement records, supplemental homicide reports and death certificates on individuals who died by lethal violence (suicide, homicide and accidents). Compilation from multiple sources minimises weaknesses in individual data sources, including classification problems. The number of US states participating in the programme has grown from seven in 2003 to all 50 US states by 2020. In this analysis, I include only suicide decedents who resided in the 25 states that participated in NVDRS for all 6 years between 2015 and 2020 and had complete information (N=103 817). (Those states are AK, AZ, CO, CT, GA, HI, KS, KY, ME, MD, MA, NC, NJ, NM, OH, OK, OR, RI, SC, UT, VA and WI). Several states (CT, GA, KY, MI, NJ, RI and SC) were disproportionately likely to have cases dropped due to missing information on the circumstances surrounding the suicide.

Prevalence of substances
To gain insight into the substances surrounding suicide deaths and how they may have changed between 2015 and 2020, I examine the top ten substances identified in available toxicology reports of suicide decedents. The presence of any level of substance in the body would produce a positive toxicology report for that substance. A few states conduct toxicology testing on virtually all decedents, but the testing rate in other states is lower due to administrative and budgetary reasons.[26] In addition, the frequency with which substances are tested varies, with tests for alcohol most common. Toxicology reports are missing for 28.1% of the 103817 suicide decedents included in this study. To identify possible missing data bias, sensitivity analyses were conducted using data only for the eight states with a toxicology test rate of at least 90%; toxicology reports were

missing for 5% of decedents across these eight states (AL, CT, MD, MN, NH, NC, RI and UT). The substantive findings are similar to those for the full sample, indicating that missing data bias is minimal. In terms of prevalence, the one noteworthy difference is that antidepressants, rather than alcohol, are the leading substance identified in toxicology reports. However, this difference is to be expected given the high prevalence of mental disorders (and antidepressant use) among suicide decedents. This high prevalence will be detected in states with very high toxicology test rates but less so in states that conduct toxicology only when there are reasons to suspect substance use (eg, empty bottles or a family member told investigators of substance use). Trends over time in the prevalence of substances align with those of the full sample. These sensitivity analyses are included in the online supplemental appendix for reference.

Factors associated with substance use circumstances among suicide decedents

I estimate a three-level mixed effects logistic regression model to determine how individual and contextual factors are associated with the probability of a drug or alcohol abuse circumstance surrounding a suicide death.

Dependent variables

Models are run separately on two dependent variables—drug abuse and alcohol problems—to distinguish between major types of substance use circumstances. These outcomes are measured as binary variables coded 1 if drug abuse (alcohol problem) was identified by NVDRS coders as a precipitating circumstance surrounding the suicide and 0 otherwise. Information on precipitating circumstances underlying violent deaths is the defining feature of NVDRS. Through careful examination of details from investigative reports compiled by Medical Examiners and Law Enforcement, trained coders determine the presence or absence of a set of demarcated circumstances that contributed to the violent death. Substance use circumstances are determined to be present if the investigation reports indicate that the decedent was perceived by themselves or by others as having a problem with, or being addicted to, the substance. There does not need to be any indication that the substance directly contributed to the death to be coded as present, nor are these circumstance variables coded according to the toxicology findings, as multiple reasons could explain the presence of the substances. (For more detail, the full NVDRS codebook entry for the 'drug abuse' and 'alcohol problem' circumstances is included in the online supplemental appendix). Other defined circumstances in the NVDRS include interpersonal problems (eg, disputes with family or friends), external problems (eg, job or financial issues) and personal problems (eg, mental or physical health issues), one or more of which may precipitate a suicide death. The dependent variables thus identify decedents who had either a drug abuse or alcohol problem as a precipitating factor, whether alone, together or in combination with other circumstances.

Independent variables

I include several independent variables measured at the individual and contextual levels. The model incorporates a number of individual-level decedent characteristics known to be associated with substance use and suicidal behaviour: age, gender, race, ethnicity, nativity, marital status and educational attainment.[27] I also incorporate the method used by the decedent to die by suicide; individuals who abuse substances may be more likely to die by poisoning due to access to a lethal means (eg, prescription drugs).[28] Finally, the presence of other life problems such as a mental health issue or financial difficulties, which may be related to the likelihood of a substance use circumstance,[9] are included in models. Note that according to the NVDRS codebook, such mental health circumstances include those disorders and syndromes listed in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, with the exception of alcohol and other substance dependence (as these are captured with separate variables).

The decedents are nested within 1897 counties located within the 25 states included in the analysis, and I also control for the context in which decedents resided. County-level measures of median household income and income inequality (captured by a Gini coefficient) are included to measure the economic context of the places in which decedents lived. Given the attention paid to deaths of despair in rural white communities,[29 30] measures of the percentage of a county's population that is rural and non-Hispanic white are included. These county-level measures are available through the University of Wisconsin Population Health Institute and the Census Bureau for the 6-year period of study. Diagnostics indicate that multicollinearity does not pose a problem.

The policy contexts of states vary in important ways that influence population health. To capture variation that may be particularly relevant to drug and alcohol abuse.[31] I incorporate measures of the percentage of a state's population that has unmet drug treatment and unmet alcohol treatment, which are based on individual self-reports of needing but not receiving treatment for drug or alcohol use at a specialty facility in the past year (National Survey on Drug Use and Health (NSDUH), Substance Abuse and Mental Health Services Administration (SAMHSA)). These variables are available annually in the State Health Rankings database supported by the Kaiser Family Foundation. See table 1 for descriptive statistics for the dependent and independent variables.

Statistical model

To summarise, the estimated model takes the following form:

$$\log(p/(1-p))_{ics} = \alpha + \beta X_{ics} + \beta X_{cs} + \beta X_s + u_c + u_s$$

where p is the probability of a drug abuse or alcohol problem surrounding a suicide for individual i; α is the intercept coefficient; β is the estimated parameters for X, the independent variables measured at the individual, county and state levels; and u_c and u_s are the random

Table 1 Descriptive statistics, NVDRS 2015–2020

	%/mean	SD
Individual characteristics		
Outcome		
Drug abuse	17.90	38.34
Alcohol problem	19.49	39.61
Demographics		
White (non-white)	88.52	31.88
Hispanic (non-Hispanic)	6.12	23.96
Age in years	46.36	18.78
Male (female)	77.34	41.86
College degree (no college degree)	18.76	39.04
Foreign born (not foreign-born)	4.20	20.05
Marital status (married)		
Divorced	21.52	41.09
Separated	3.26	17.77
Single	38.77	48.72
Widowed	5.62	23.03
Method (firearm)		
Poisoning	13.85	34.54
Hanging	28.53	45.15
Other	6.52	24.69
Other circumstances		
Mental health problem (no such problem)	51.31	49.98
Financial problems (no such problem)	8.72	28.22
County characteristics		
Median household income (000)	51.08	13.92
Gini coefficient	0.45	0.03
% rural	52.33	32.19
% non-Hispanic white	75.95	19.31
State characteristics		
% with unmet drug treatment	6.59	1.12
% with unmet alcohol treatment	11.18	1.61

Analyses are based on 103 817 decedents nested within 1897 counties and 25 states, 2015–2020. Reference category in parentheses.
NVDRS, National Violent Death Reporting System.

intercepts for counties and states. The estimated models account for the clustering of deceased individuals within counties and states by allowing for random variation in the intercepts across counties and states and adjusting SEs. Moreover, the model permits estimation of county and state covariate effects, unlike a state fixed effects model which estimates within-context effects only. A comparison of the substantive results indicates that findings from the fixed and random effects models are very similar. The significance of coefficients is assessed using unadjusted p values. I present results using average marginal effects (AMEs) to facilitate comparisons across covariates.[32] Models are estimated using the melogit command in Stata V.18.

RESULTS

Prevalence of substances involved in suicide deaths

Table 2 identifies common substances found in toxicology reports of suicide decedents between 2015 and 2020. A total of 23 564 decedents had toxicology reports indicating that alcohol was present in their system at the time of death, accounting for a little over a third (37.3%) of those who were tested and 22.7% of all decedents in the sample. Antidepressants, benzodiazepines and opiates (illicit forms, including substances such as heroin and fentanyl, make up about 22% of positive tests for opiates) comprise the next three most-commonly found substances, an indicator of the role that pain, depression and anxiety play in suicide deaths. Other substances commonly found in suicide decedents include a mix of legal and illicit drugs and other household poison agents.

The prevalence of substances identified in toxicology reports of suicide decedents changes over time (figure 1). Positive tests for antidepressants, opiates and benzodiazepines declined over the study period. Note that antidepressants are not typically associated with recreational use. Although they appear in the toxicology reports of suicide decedents (mental health disorders are common among this group), NVDRS does not categorise the use of antidepressants as a drug abuse circumstance unless there is some indication that the decedent was misusing the antidepressants (eg, the decedent told friends they were misusing antidepressants). The distribution of positive tests for prescription and illicit forms of opiates changed due to declines in positive tests for prescription opiates and increases for illicit opiates such as heroin and fentanyl over the period. Estimates indicate that illicit opiates comprised 15.5% of all positive opiate tests in 2015, and that figure increased to 30.8% by 2020. Positive tests for marijuana (the increase in marijuana between 2017 and 2020 is statistically significant at p<0.05) and amphetamines also increased. The prevalence of alcohol remained mostly constant over the period, although highest in 2015. Thus, while in 2015, antidepressants, alcohol and benzodiazepines were most commonly found in decedents, marijuana overtook benzodiazepines by 2020 as the third most frequently found substance.

Factors associated with substance use circumstances underlying suicide

Table 3 displays the results from the mixed effects regression model examining the individual and contextual characteristics associated with drug abuse and alcohol-related circumstances among suicide decedents. Looking first at drug abuse, this circumstance increased in the latter part of the 2010s. Specifically, the AMEs for years 2016–2020 relative to 2015 are all positive and statistically

Table 2 Common substances identified and/or tested in toxicology reports of NVDRS suicide decedents, 2015–2020

	Positive cases	Cases tested	Positive/tested	Tested/total	Positive/total
Alcohol	23 564	63 102	37.3%	60.8%	22.7%
Antidepressants	11 541	34 435	33.5%	33.2%	11.1%
Benzodiazepines	11 427	49 235	23.2%	47.4%	11.0%
Opiates	11 237	51 103	22.0%	49.2%	10.8%
Illicit forms	2506				
Marijuana	9449	41 626	22.7%	40.1%	9.1%
Amphetamine	5447	48 418	11.2%	46.6%	5.2%
Anticonvulsants	4225	28 139	15.0%	27.1%	4.1%
Cocaine	2859	49 322	5.8%	47.5%	2.8%
Antipsychotics	2655	28 105	9.4%	27.1%	2.6%
Carbon monoxide	2207	7715	28.6%	7.4%	2.1%
Barbiturates	839	41 136	2.0%	39.6%	0.8%

Toxicology data are missing for at least 28.1% (29 157) of decedents.
Illicit opiates include non-prescription forms, such as heroin and fentanyl.
NVDRS, National Violent Death Reporting System.

significant. For example, after adjustment for other explanatory variables, the probability of a decedent dying from suicide in 2020 with a drug abuse circumstance is 2.6 percentage points higher than that of a suicide decedent in 2015. The probability of an alcohol problem as a suicide circumstance is similarly elevated in years 2016–2020 relative to 2015.

Decedents who are white, Hispanic, male and do not possess a college degree are more likely to have a drug abuse circumstance. Although statistically significant, the gender differential is relatively small (AME=0.006). On the other hand, education is highly protective—the probability of drug use underlying a suicide is associated with a reduction of almost 10 percentage points (AME=−0.099) for decedents with a college degree relative to those with less education. Foreign-born status similarly is associated with a lower probability (AME=−0.078) of a drug-related circumstance. As an example of how these factors combine to affect absolute risk, the probability of a drug abuse circumstance for a white native-born decedent with no college degree is predicted by the model to be 0.20 (0.18, 0.22), but only 0.05 (0.04, 0.06) for a non-white foreign-born college-educated decedent.

The probability of a drug abuse circumstance increases with age (AME$_{age}$=0.017) but then declines after age 73 (AME$_{age}^2$=−0.0002), holding all else constant. Those
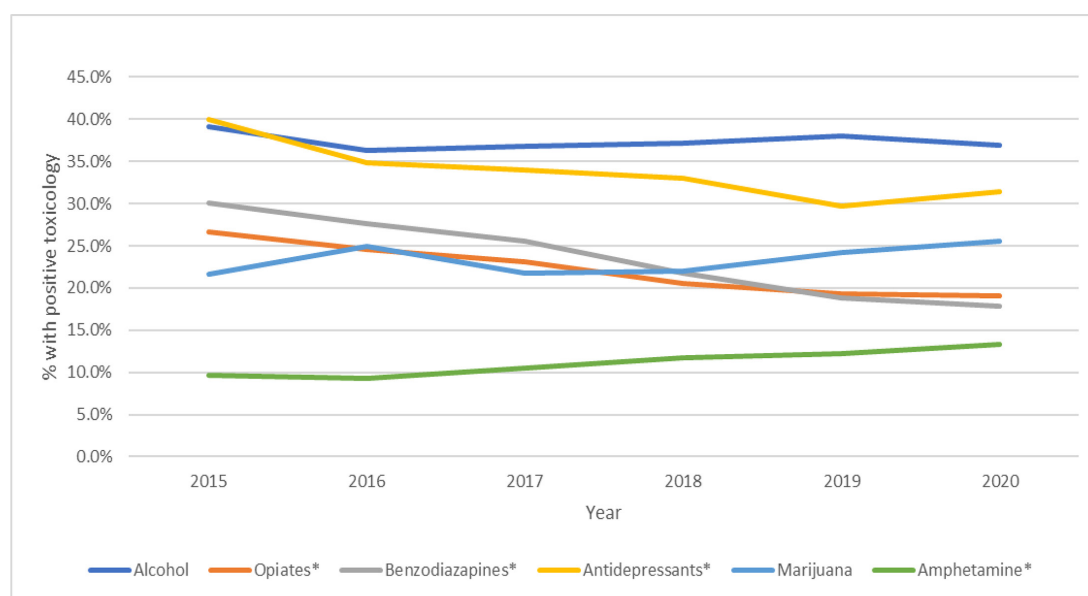

Figure 1 Percentage of NVDRS decedents with positive test result among those with toxicology reports, 2015–2020. *Trend is significant at p<0.05. Estimates indicate that illicit opiates comprised 15.5% of all positive opiate tests in 2015; that figure increased to 30.8% by 2020.

Table 3 Individual and contextual factors associated with likelihood of drug or alcohol use circumstances among suicide decedents, 2015–2020

	Drug abuse				Alcohol problems			
	AME	LCL	UCL		AME	LCL	UCL	
Individual characteristics								
Demographics								
White (non-white)	0.038	0.031	0.045	***	0.033	0.025	0.041	***
Hispanic (non-hispanic)	0.013	0.004	0.021	**	−0.005	−0.015	0.005	
Age in years	0.017	0.016	0.019	***	0.023	0.021	0.024	***
Age in years squared	−0.0002	−0.0003	−0.0002	***	−0.0002	−0.0003	−0.0002	***
Male (female)	0.006	0.0003	0.011	*	0.055	0.049	0.062	***
College degree (no college degree)	−0.099	−0.108	−0.090	***	−0.045	−0.052	−0.038	***
Foreign born (not foreign born)	−0.078	−0.093	−0.063	***	−0.035	−0.048	−0.021	***
Marital status (married)								
Divorced	0.052	0.045	0.060	***	0.033	0.027	0.040	***
Separated	0.048	0.035	0.060	***	0.027	0.014	0.039	***
Single	0.060	0.053	0.068	***	0.010	0.004	0.017	**
Widowed	0.066	0.051	0.081	***	0.024	0.011	0.038	***
Method (firearm)								
Poisoning	0.108	0.099	0.117	***	0.006	−0.001	0.014	
Hanging	0.071	0.064	0.078	***	−0.003	−0.008	0.003	
Other	0.058	0.049	0.068	***	−0.038	−0.048	−0.027	***
Other circumstances								
Mental health problem (no such prob)	0.028	0.023	0.033	***	0.046	0.041	0.052	***
Financial problems (no such problem)	0.006	−0.001	0.014		0.020	0.012	0.027	***
County characteristics								
Median household income (000)	−0.0005	−0.001	−0.0002	***	0.001	0.000	0.001	***
Gini coefficient	0.113	−0.008	0.233		−0.029	−0.167	0.109	
% rural	−0.0001	−0.0003	0.0000		0.0000	−0.0002	0.0002	
% non-Hispanic white	0.0005	0.0002	0.001	***	−0.0001	−0.0004	0.0002	
State characteristics								
% with unmet drug treatment	0.012	−0.003	0.028					
% with unmet alcohol treatment					0.022	0.012	0.031	***
Year (2015)								
2016	0.013	0.005	0.020	***	0.008	0.000	0.016	*
2017	0.023	0.016	0.031	***	0.017	0.008	0.025	***
2018	0.018	0.011	0.026	***	0.024	0.016	0.032	***
2019	0.015	0.007	0.023	***	0.021	0.012	0.029	***
2020	0.026	0.018	0.035	***	0.025	0.016	0.034	***

N=103 817. State and county random variance are significant at p<0.05. Reference category is in parentheses.
*p<0.05, **p<0.01, ***p<0.001.
AME, average marginal effects; LCL, lower confidence limit; UCL, upper confidence limit.

who are married are less likely to have a drug abuse circumstance than all other marital status categories. Relative to firearms, the mechanisms of poisoning, followed by hanging and other methods, are associated with a higher probability of drug abuse circumstances (AME=0.108, 0.071 and 0.058, respectively). Drug abuse circumstances tend to co-occur with mental health problems (AME=0.028) but are not associated with financial problems.

Individual characteristics associated with alcohol-related circumstances are similar with a few exceptions. White, male, less educated and native-born decedents
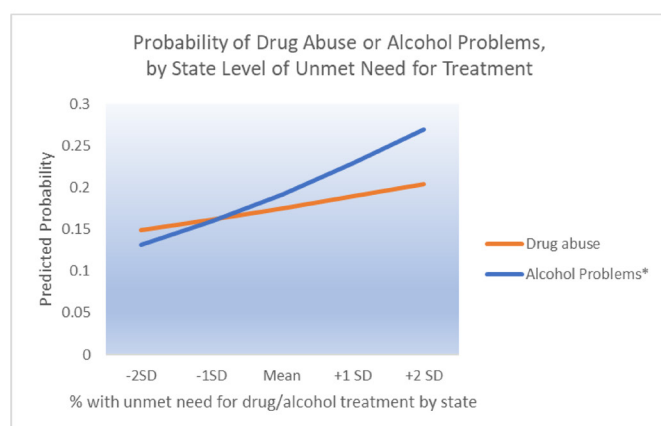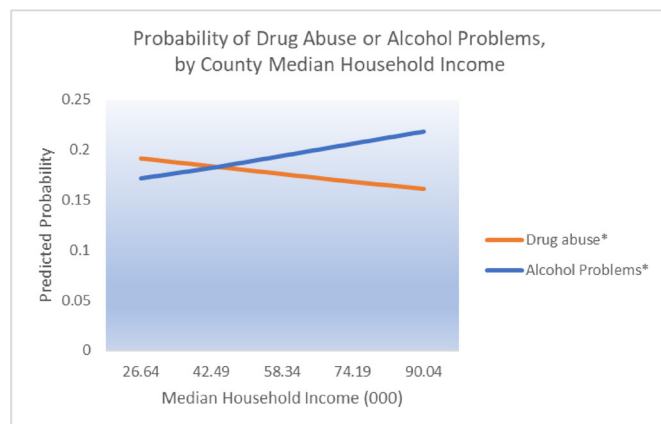
Figure 2 Predicted probabilities of substance use circumstances, by select contextual factors. *p≤0.05.

exhibit a higher probability of an alcohol problem surrounding their suicide. The probability of an alcohol problem circumstance is 5.5 percentage points higher for men compared with females. The differentials by education and nativity status are about half the size of those observed for drug abuse circumstances (AME=−0.045 and −0.035, respectively). There is no difference in Hispanic ethnicity with respect to alcohol problems as a suicide circumstance. 'Other' mechanisms are less likely than firearms, but I find no difference among the other means of suicide. In addition to mental health problems, financial problems are associated with a higher probability of alcohol problems as a circumstance.

Geographical variation in substance use circumstances is also apparent. Residing in counties with a higher median household income is associated with a lower probability of a drug abuse circumstance but a higher probability of an alcohol-related circumstance (see figure 2). The predicted probability of an alcohol circumstance rises from 0.17 to 0.22 for decedents residing in the poorest and wealthiest counties, respectively. For drug abuse circumstances, the predicted probability falls from 0.19 for decedents in the poorest counties to 0.16 for those residing in the wealthiest counties.

Unmet need for treatment at the state level is positively associated with both substance abuse circumstances but

significantly so only for alcohol problems. The predicted probability of an alcohol-related circumstance is 0.13 for decedents residing in states that fall 2 SDs below the mean percent reporting unmet need of alcohol treatment. That predicted probability more than doubles to 0.27 for those in states falling 2 SDs above the mean percent reporting unmet need.

Residing in counties with a higher percentage of non-Hispanic white people is associated with an elevated probability of a drug abuse circumstance. However, after adjusting for individual-level characteristics, this geographical characteristic is not significantly associated with alcohol problems as a suicide circumstance.

DISCUSSION

Substance problems are important precipitating factors to suicide in the USA today, and the probability of such circumstances surrounding suicide appears to have increased in the latter half of the 2010s concomitant with rising drug overdose rates.[33] The examination of toxicology reports reveals some interesting patterns. While the prevalence of alcohol, the most common substance identified in toxicology reports among suicide decedents, remained fairly stable over the study period, the presence of opioids, benzodiazepines and antidepressants decreased over time. The trends for opioids align with what has been observed nationally. Following the introduction of CDC guidelines in 2015–2016 that place limits on prescribing opioids,[22] patients with one or more prescriptions for opioids, benzodiazepines or concurrent prescriptions dropped between 2016 and 2019.[34] This pattern is also reflected in the toxicology reports of suicide decedents included in this study, for whom positive tests for prescription opiates, which comprise the majority of opiates in this category, fell over the period. However, the presence of illicit opioids such as heroin and fentanyl in suicide decedent toxicology reports increased during the study period, consistent with national trends in overdose rates,[25] although they remained a smaller fraction of the opiates identified in toxicology reports. These patterns among suicide decedents appear to be in line with national evidence pointing to the substitution of heroin and synthetic opiates such as fentanyl for prescription opioids, whether due to an addiction or to insufficient treatment for chronic pain, that have been widely documented in the literature.[35]

Estimates indicate that the presence of antidepressants in toxicology reports among suicide decedents also declined, in contrast to national trends which indicate that antidepressant use continued to increase over the period.[36] Given increased attention and regulation surrounding prescription drug abuse, it is possible that suicide decedents with substance use disorders may have become less likely to receive the treatment they need for underlying depression and/or anxiety, even though recommendations are that co-occurring disorders be treated simultaneously.[37] Nonetheless, it is important to

note that the percentage of suicide decedents using anti-depressants, as estimated by positive toxicology reports, is high. These trends merit further investigation.

Conversely, the presence of marijuana and amphetamines in toxicology reports of suicide decedents rose over the period, consistent with national trends in use.[38 39] Recreational marijuana use is now legalised in 24 states and decriminalised in another seven,[23] and studies indicate that cannabis legalisation is associated with increased cannabis use.[40] Moreover, it is possible that decedents who are unable to effectively manage chronic pain due to changing rules about opioid prescribing may turn to medical marijuana as an alternative source of relief.[41] Yet, evidence shows a link between marijuana use and suicidal behaviours, perhaps because of the higher levels of THC found to be associated with increased levels of psychotic disorders and other adverse effects.[42] Aggression and psychosis prior to suicide have also been documented for methamphetamine users.[43] The rising use of stimulants such as methamphetamines has been attributed to several factors, including increases in supply, a rise in polysubstance use (especially the use of methamphetamines with opioids to achieve a stronger high), and the substitution of opioids with methamphetamines.[39] The CDC, in recognition of the importance of effective pain management, released additional guidelines for prescribing opioids for pain in 2022. These guidelines emphasise open communication between provider and patient, especially for those (eg, members of marginalised groups, women, older individuals and those with substance use disorders) who may be at greater risk for receiving inadequate pain management.

The individual characteristics associated with substance use circumstances for suicide decedents tend to support what we know about patterns of substance use and of suicide.[27] Several findings are noteworthy in the recent period. First, although the models indicate an increased likelihood of drug abuse circumstances for male suicide decedents, the size of the gender differential is negligible, which may reflect the sharp increase in substance use disorders among American females in recent years. Historically, males exhibit a greater prevalence of substance use disorders (and they continue to have a much higher rate of suicide mortality), but changing cultural and social norms around gender roles may have altered access to and attitudes towards substance use among women.[13] Research also indicates some biological differences between sexes in how substances are metabolised, and studies show that women are more likely to have co-occurring mental health disorders with substance use disorders,[13] with possible implications for suicidal behaviour. In addition, women experience more acute and chronic pain for which they were prescribed opioids without much scrutiny before 2015; women thus were susceptible to possible addiction and to seeking alternative sources of pain relief with changing regulations around opioid prescriptions. Men continue to die at higher rates from opioid overdoses, but the rate of change in overdoses between 1999 and 2016 was larger for women than men (583% and 404%, respectively),[44] and women comprise 54% of opioid-related suicidal drug overdoses.[45] Research should continue to monitor this emerging trend among women and the connection between drug use and suicide.

Second, the results underscore the important role of a college degree in reducing the likelihood of drug and alcohol-related circumstances in suicide, a finding that resonates with a large body of literature delineating the ways in which less educated Americans are struggling today.[46] The list is long: the loss of economically stable jobs due to declines in manufacturing and the rise of globalisation, technology and the service sector, a declining ability to purchase a home, reduced or no access to health insurance, increasing debt, growing economic inequality, and the loss of the American Dream. Researchers cite these trends as contributing to a sense of despair that has produced increases in deaths from substance use and suicide among the less-educated.[47] This study highlights that these forces compound to increase mortality among the group and reinforces the need to address the long-standing concerns of this segment of our society.

Relatedly, and consistent with prior work on drug-related mortality,[17 18] the risk of a drug abuse circumstance precipitating a suicide is higher in counties that are poor, have greater income inequality and a greater percentage of non-Hispanic white people. To the extent that such environments contribute to personal deprivation and stress as well as frustration and hopelessness, residents may turn to drugs for escape and relief. Employment opportunities in such contexts are more likely to involve manual work that elevates the risk of physical ailments, injuries and pain, yet they often fail to provide good access to mental and physical healthcare. Finally, sources of support—neighbourhood ties, community associations or religious institutions—are often diminished in poorer, more unequal environments.[48 49]

In contrast, alcohol problems are more likely to be associated with suicide mortality in wealthier counties. Research shows that those of higher socioeconomic status (SES) consume as much or more alcohol as those of lower SES,[50] a pattern that may reflect more disposable income and/or norms more supportive of frequent alcohol use in wealthier communities.[51 52] In this sample, white decedents have an elevated probability of alcohol problems surrounding suicide relative to decedents of other races, suggesting unique pathways linking alcohol use and suicide that depend on race and are consistent with prior work showing interactions between race, alcohol use and geographical location.[19] Finally, and significantly, the likelihood of alcohol problems as a precipitating suicide circumstance is reduced in states that have lower unmet need for treatment for white and non-white decedents, suggesting an important intervention pathway.

This work has several limitations, some of which are inherent to NVDRS and are described elsewhere.[53] The completeness of toxicology testing varies by state, and

the process by which decisions are made with respect to testing can vary; thus, these results should be interpreted with caution, especially if there are changes made within states over the time period investigated.[54] The analyses are based on an incomplete sample of states and may not be generalisable to the entire USA, although the 25 states examined exhibit variation in size and region among other attributes. Finally, the state-level measures of unmet need for treatment are self-reported and subject to sampling error.

CONCLUSIONS

The high levels of substance use in the USA continued to be associated with suicide deaths between 2015 and 2020. Alcohol remains a potent factor surrounding suicide deaths, and the declining prevalence of prescription opioids and growing presence of illicit opioids and marijuana in toxicology reports of suicide decedents merits particular attention, especially if individuals are turning to alternative drugs to self-medicate physical and mental pain. After adjusting for individual characteristics, the likelihood of substance-related issues contributing to suicide deaths varies in important, and sometimes unanticipated, ways by context that are suggestive of different mechanisms that may underlie the associations between substance (by type) and death by suicide. Yet, unmet need for drug and alcohol treatment at the state level generally exhibits a significant positive association with the likelihood of substance use circumstances, suggesting a promising place for intervention. The findings underscore the multiplicative ways in which the scourge of substance abuse affects Americans' health and highlight the ways in which a variety of approaches may have spillover effects for suicide prevention.

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