Postmortem Presence of Drugs and Method of Violent Suicide

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Abstract

The link between substance use and suicide is well established. However, little research analyzes how substance use is related to the method of suicide. This article analyzes how specific drugs are associated with method of suicide, a critical topic because drug use bears on the etiology of suicide and may lead to policies aimed at deterring suicide. We use the Colorado Violent Death Reporting System and logistic regression to examine postmortem presence of drugs among 3,389 hanging and firearm suicides in Colorado from 2004 to 2009. Net of demographic controls, we find that opiates are positively associated with firearms (odds ratio [OR] = 1.92, 95% confidence interval [CI] = [1.27, 2.86]) while antidepressants are positively associated with hanging (OR = 1.45, 95% CI = [1.04, 2.03]). For cocaine and opiates, the association between drug use and violent method vary by educational attainment. Importantly, knowledge of the presence and type of specific drug is strongly associated with the method of suicide.

Keywords

drug use, suicide, suicide method, toxicology, National Violent Death Reporting System (NVDRS)

Introduction

Suicide prevention is a public health priority (Goldsmith, 2002; Rockett, 2010; Satcher, 1999). In the United States, one of the major objectives of Healthy People 2020 (2010) is to reduce suicide rates by 10%. Despite increased attention, from 2000 to 2010, suicide rates increased by 15% (Rockett et al., 2012), making suicide the 10th overall leading cause of death in the United States and the leading death from external causes, which include deaths due to violence and accidents (Hoyert & Xu, 2012; Rockett et al., 2012). In 2011, an American died by suicide every 14 min—totaling over 38,000 suicides for the year (Hoyert & Xu, 2012). Beyond their tragic consequences for surviving friends and family members, suicides cost the U.S. economy an estimated US$5 to US$13 billion annually in lost earnings and medical costs (Yang & Lester, 2007).

Because of its public health importance, the causes, correlates, and consequences of suicide have been studied thoroughly (Durkheim, 1897; Eshun, 2003; Inskip, Harris, & Barraclough,

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1998; Qin, Mortensen, Agerbo, Westergard-Nielsen, & Eriksson, 2000). One of the most consistent findings of this research is that substance use and abuse is one of the strongest predictors of suicide (Brent, 1995; Centers for Disease Control and Prevention [CDC], 2010; Kung, Pearson, & Liu, 2003; Sheehan, Rogers, Williams, & Boardman, 2013). To date, little is known about the relationship between substance use and method of suicide. The relationship between substance use and suicide is a critical topic because drug use bears on the etiology of suicide and as such a greater understanding of the relationship between drug use and suicide potentially may lead to policies aimed at deterring suicide. For example, the causes of suicide may differ between someone prescribed antidepressants for long-term depression and someone self-medicating with opiates in light of chronic exposure to stressors, pain, or major stressful life events.

Using toxicology reports from suicide decedents in the state of Colorado, we examine the associations between the postmortem presence of licit and illicit drugs and method of suicide. Colorado has one of the highest age-adjusted suicide rates in the United States as well as some of the highest levels of drug use and thus serves as a useful and important context for this analysis (Murphy, Xu, & Kochanek, 2013; Sheehan et al., 2013). We aim to explore how specific drugs are associated with the method of suicide net of social and demographic characteristics. Because of increasing differences in rates of suicide and drug use when stratified by level of educational attainment (Abel & Kruger, 2005; Miech, 2008), we also examine whether level of educational attainment moderates drug use.

Background

Drug Use and Suicide

For decades, research has shown that illegal drug use and abuse are associated with higher levels of suicide ideation, attempts, and, ultimately, deaths (Brent, 1995; Erinoff, Compton, & Volkow, 2004; Price, Risk, Haden, Lewis, & Spitznagel, 2004). Indeed, the CDC (2010) ranks drug and alcohol abuse second to major depression as the one of the strongest risk factors for suicidal behavior. However, illegal drug use is prone to misreports on surveys, and the relationship between drug use and suicide may be dramatically underestimated (Magura & Kang, 1996; Single, Kandel, & Johnson, 1975). This underestimation may be more severe around the time of death: Even if a respondent gives accurate responses on a survey, drug use in periods of elevated risk of suicide or around the critical period right before death may differ substantially from the individual's typical consumption (Hawton, 2005). In addition, third-party reports or investigations of the scene of death may underestimate the prevalence of drugs when compared with toxicology testing (Gruszecki, Booth, & Davis, 2007). Research that focuses solely on current drug users or those with a drug addiction makes it difficult to estimate the prevalence of drug use among the general public near the time of death (Oyefeso, Ghodse, Clancy, & Corkery, 1999). Our data include toxicology reports of drug use around the time of death for the population of suicide decedents in a U.S. state over the course of 6 years, allowing us to overcome misreporting of drug use on surveys.

While toxicology reports may be the ideal way to examine how drug use is associated with method of suicide, they are not problem-free. The third leading method of suicide is intentional self-poisonings (which comprises roughly 23% of all the suicides in Colorado during our study period), which, by definition, include drugs or substances in the system at the time of death. To avoid this tautology, we examine only "violent" firearm and hanging/strangulation/suffocation suicides (henceforth hanging; Dumais et al., 2005). These two methods comprise the vast majority of U.S. suicides, 71% of the Colorado sample, and 78% of the National Violent Death Reporting System (NVDRS) sample (Conner et al., 2014).

Substance abuse is strongly associated with suicide among adolescents (Erinoff et al., 2004; Hallfors et al., 2004) and adults (Kung et al., 2003; Rossow, Romelsjo, & Leifman, 1999). Yet, a

consideration of substance abuse as a broad topic may obscure the unique relationships between specific drug use and suicide risk. In fact, previous work demonstrates associations between *specific* drugs and suicide risk. For example, Kung and colleagues (2003) show that compared with adults who died by natural causes, males and females who use marijuana are 2.3 and 4.8 times as likely to commit suicide. Similarly, heroin users are estimated to be 14 times as likely to commit suicide compared with their non–drug-using peers (Darke & Ross, 2002). According to a meta-analysis, compared with the general public, opiate addicts face an elevated risk of suicide (Wilcox, Conner, & Caine, 2004). Antidepressants are correlated with *decreased* suicide risk (Gibbons, Hur, Bhaumik, & Mann, 2005; Grunebaum, Ellis, Li, Oquendo, & Mann, 2004), and there is mixed evidence about the increased risk of suicide among adolescents who are taking antidepressants (Brent, 2004; Gibbons, Hur, Bhaumik, & Mann, 2006; Gunnell & Ashby, 2004). Importantly, those on antidepressants are a highly select at-risk population (Isacsson, Bergman, & Rich, 1996; Sleath & Shih, 2003) who may seek antidepressants to prevent suicide.

Although research has linked substance use and abuse to suicide, less scholarship has focused on how drug use near the time of death is associated with the *method* of suicide. The majority of this work analyzes acute alcohol use before death and finds that associations between alcohol use and method of suicide varies by demographic characteristics (Caetano et al., 2013; Conner et al., 2014; Kaplan et al., 2013). Conner et al. (2014) showed that relatively young adults were more likely to use alcohol rather than poisoning before using a firearm and hanging. There are also distinct variations by race and ethnicity. For example, Asians are more likely to use alcohol in poisoning deaths, whereas non-Hispanic Blacks are least likely to use alcohol during hangings (Conner et al., 2014). The association between alcohol use and selected method of suicide also varies by gender (Kaplan et al., 2013). While the degree to which alcohol influences suicide method has been studied, drug use has not. Therefore, we exclusively analyze drugs rather than include alcohol.

In addition, less research has analyzed drug use and suicide method, but there are notable exceptions. Sheehan et al. (2013) demonstrated that the postmortem presence of specific substances among victims of violent deaths helped differentiate between cases of suicide and homicide. Darke and Ross (2002) concluded that heroin users were surprisingly less likely to commit suicide by overdose than use other methods. Using suicide decedent data from New York City in 1985, Marzuk, Tardiff, Leon, and Stajic (1992) determined that decedents who tested positive for cocaine were twice as likely to use firearms as any other method. However, rates of gun ownership vary by state and city, and the relationship may have changed over time. Rather than focusing specifically on the high-risk drug-using population or relying on survey reporting of drug use, we build on previous research by including *all* Colorado violent suicide decedents from 2004 to 2009, a much larger sample than those examined in previous investigations. As mentioned above, we only analyze hanging and firearm suicides due to them being considered violent (and classified as such see, Dumais et al., 2005), their high degree of lethality (Shenassa, Catlin, & Buka, 2003), and because they are the two most common methods of suicide in Colorado and the United States (Conner et al., 2014). In addition, we include all drug use in a multivariate rather than descriptive framework, thereby statistically controlling for socioeconomic and demographic factors. Finally, this may be the first study to examine how amphetamines are associated with methods of suicide.

Drug Use, Educational Attainment, and Suicide Method

It is also important to consider that the association between drug use and suicide method may vary by level of educational attainment. Previous research indicates that drug use varies significantly over time by educational attainment; those with lower levels of education are more likely to use and less likely to quit cocaine (Miech, 2008), abuse alcohol (Crum, Helzer, & Anthony,

1993), and face worse health than more educated drug users (Galea & Vlahov, 2002). More attention has been paid to how lower levels of education are associated with the likelihood of committing suicide (Abel & Kruger, 2005), socioeconomic disparities in suicide risk (Qin, Agerbo, & Mortensen, 2003), and how these disparities in suicide rates have widened over time, particularly with the large-scale adoption of antidepressants (Clouston, Rubin, Colen, & Link, 2013).

A much smaller body of work has examined whether education is associated with the method of suicide. For example, Shojaei et al. (2014) showed that in Iran, hanging is the most frequent method of suicide among those with lower levels of education, but this is not the same for those with higher levels of education. However, we are aware of no research that analyzes how educational attainment is associated with suicide method in the United States. This is particularly relevant as the prevalence of suicide by hanging steadily increased in the United States from 2000 to 2010 (Baker, Guoqing, Wilcox, & Baker, 2013). It is possible that the presence of substances may exacerbate the social patterning of suicide method. Said differently, the presence of drugs among those with low levels of education may be strongly associated with suicide from hanging but have a negligible influence among those with higher levels of education. But it is also possible that the social factors among those with the greater social risks (e.g., those with relatively low levels of education) drive the comorbid risk of both drug use and suicide, whereas in more stable environments, drug use denotes a stronger indicator of suicide risk for individuals. Thus, it is possible that the association between the presence of drugs and the method of suicide will be significant for those with higher levels of education but negligible among those with lower levels of education. To date, however, it is unclear whether the association between drug use prior to death and method of suicide varies by level of education. Indeed, other research has indicated that there are social patterns between substance use and suicide method. For example, Conner and associates (2014) showed that Blacks are less likely than Whites to have used alcohol prior to hangings. Due to the social patterns found in other studies connecting drug use to suicide method and the strong connection between education and drug use, we hypothesize that substance use before death moderates the association between social factors such as educational attainment and method of suicide.

Aims

Our analysis has two major objectives. First, we document whether the use of specific drugs before death is associated with violent method of suicide. Hanging and firearms comprise 78% of all suicides in the NVDRS (Conner et al., 2014). While there are other methods of violent suicide (such as cutting, using a blunt object, or self-immolation), individually and collectively they denote a relatively small proportion of suicides. As a result, the different mechanisms of suicide have very small cell sizes that limit our ability to analyze them statistically. Due to the tautological nature of drug consumption before death and drug overdose, we also exclude intentional self-poisoning (which comprise just below 23% of the total suicides among those 18 and older in Colorado from 2004 to 2009) or other causes from the following analysis. We build on previous research by focusing exclusively on drug use and controlling for demographic characteristics. Second, we explore whether the association between drug use and method of suicide significantly varies by level of educational attainment.

Method

Data

The data come from the Colorado Violent Death Reporting System (COVDRS). Colorado is one of 32 states receiving federal funding to participate in the NVDRS (http://www.cdc.gov/

ViolencePrevention/NVDRS/index.html). The NVDRS, administered by the CDC, was established in 2002 to provide high-quality data on all types of violent deaths including suicide, homicide, unintentional firearm fatalities, and deaths of undetermined intent (CDC, 2010; Paulozzi, Mercy, Frazier, & Annest, 2004). The NVDRS complies and then codes data regarding the context of the death, toxicological reports, police reports, geographic location, and, crucial for this investigation, cause of death (Paulozzi et al., 2004). The cause of death codes are based on the 10th revision of the *International Statistical Classification of Diseases and Related Problems* (ICD-10; World Health Organization, 2007). Using data from 2004 to 2009, we exclude all homicide victims, individuals above age 18 (when education is often not completed), and suicide decedents who did not die from hanging or firearms. After these exclusions, our study population contains 3,389 decedents (71% of the adult Colorado suicide decedent population from 2004 to 2009), all of whom are used in every multivariate analysis. Colorado currently has the 11th highest age-adjusted suicide rate in the United States and is situated in a cluster of mountain west states which, except for Alaska and Oregon, have the highest age-adjusted suicide rates in the country (Murphy et al., 2013).

Measures

We code our dependent variable, method of suicide, into two categories based on the ICD-10 cause of death codes: suicide due to firearms, coded "0" (ICD-10 codes X72-X74), and hanging/self-strangulation, coded "1" (ICD-10 code X70). We analyze hanging, which has a lower level of lethality, relative to firearms, the most common method (69.5% of our sample), due in part to its higher likelihood of fatality (Shenassa et al., 2003). All of our samples are decedents.

The five drugs we analyze are antidepressants, opiates, cocaine, marijuana, and amphetamines. Excluding alcohol, these drugs are the most commonly tested for and confirmed in violent death decedents as measured by toxicology reports (benzodiazepines were not tested for as often as the other drugs listed). Antidepressants serve as an important control and backdrop in which to compare the magnitude of other drugs. There is considerable within-drug heterogeneity for opiates and antidepressants. For example, there are numerous forms of antidepressants and opiates, ranging from heroin to prescription drugs. Due to the COVDRS data, we are unable to differentiate different types of antidepressants or opiates. Unlike for homicide decedents, toxicology tests are not legally required for suicides but may be conducted based on circumstances of the suicide (e.g., drugs found near the place of death) or characteristics of the decedent, as such not all decedents have toxicology reports, a limitation we address in the discussion. Therefore, we represent each drug with two dummy variables, the first indicating whether it was found to be present by a toxicology test (coded "1" if present, "0" if not) and the second indicating whether a test was done at all or whether the results were missing (coded "1" if a test was not conducted or the result was missing, "0" if not). The absence of the drug is the reference category.

The COVDRS also contains detailed information regarding the demographic characteristics of the decedents. We code men "1" and women "0." Based on previous research (Conner et al., 2014), we divide age into the following set of four dummy variables: 18 to 24 (referent), 25 to 44, 45 to 64, and 65 and above. Due to small cell sizes, we operationalize race/ethnic group affiliation as a dummy variable where we code non-Whites as "1" and Whites as "0." We code marital status into the following set of five dummy variables: married (referent), never married, divorced, widowed, and missing marital status. Finally, we measure education as a dummy variable based on the number of years of education completed: less than high school/missing educational attainment (just more than 1% of our sample are missing information regarding their educational attainment; referent) and high school or greater.

Analytical Strategy

The first set of logistic regression models in Table 2 compares hanging versus firearm-related suicides. This model includes all of the drugs and controls for demographic factors to ascertain whether the association between drug use and violent suicide method withstands controls for demographic factors and, equally important, other drug use. The next set of logistic models (Table 3) includes an interaction term between the presence of drugs and educational attainment to determine whether the association of drug use significantly varies by educational attainment. We then use the postestimation values from the interaction and *Stata*'s *margins* command to graph the probabilities of drug use and education in predicting the method of suicide with all of the other controls held at their means. For a detailed overview of the calculation and interpretation of marginal effects, see Karaca-Mandic, Norton, and Dowd (2012).

Findings

Table 1 displays drug presence among suicide decedents by method of violent suicide. Overall, the testing/missing rate is relatively consistent but varied slightly by method and drug. Decedents who test positive for antidepressants had slightly higher rates of hanging (6.4%) than firearms (5.1%). The opposite pattern is apparent for opiates, where decedents who used firearms (5.9%) have almost twice as high percentages found positive than those who used hanging (3.3%). For firearms, only 3.4% of decedents test positive for cocaine, whereas for hanging, the comparable number is 6.6%. Marijuana and amphetamines have higher levels of positive tests among those who used hanging than firearms. By method, the majority of violent suicide decedents died from self-inflicted gunshot wounds (69.5%), whereas 30.5% died from hanging. The percentage not tested is relatively large but the percentage missing is very small.

The multivariate logistic regression results in Table 2 indicate significant associations between postmortem presence of drugs and method of suicide. All of the models control for age, gender, race/ethnic group, educational attainment, marital status, and missing drug values. The results of Table 2 indicate that those who tested positive for opiates are significantly less likely to use hanging than firearms (odds ratio [OR] = 0.52, 95% confidence interval [CI] = [0.35, 0.79]). However, those who test positive for antidepressants are significantly more likely to use hanging (OR = 1.45, 95% CI = [1.04, 2.03]) than firearms. There is no significant association between cocaine, amphetamines, and marijuana and method of suicide. Overall, the model that includes the five drugs (−2LL = −3,832) is a significant improvement (Likelihood Ratio (LR) = 22.07, *df* = 10, *p* < .05) over the baseline model with only demographic characteristics (−2LL = 3,854), statistically verifying our assumption that drug use is associated with the method of suicide above and beyond demographic characteristics.

Table 3 uses interaction terms to investigate whether any of the drug use associations vary significantly by educational attainment. We estimate each drug separately. We find significant interactions between the presence of drugs and education level for opiates and cocaine (*p* < .05) and some tentative evidence for amphetamines (*p* < .10). The association between opiates and suicide method (e.g., hanging compared with firearm) is significantly reduced for those who finished high school (OR = 0.68) compared with those who did not finish high school (OR = 0.14). These results also show that the association between cocaine and hanging is negative for those who did not finish high school (OR = 0.67) but positive for those who did finish high school (OR = 1.55). While the direction is negative, the interaction is not significant at the .05 level for those who did not graduate high school. Similar to cocaine, the association of amphetamines operated in different directions based on educational attainment (at the 0.1 level). There are not significant differences at the .05 level found for amphetamines, marijuana, and antidepressants. These results indicate that decedents who had less than a high school education and were not on opiates or cocaine were more likely to hang but those who did test positive for those

Table 1. Descriptive Statistics of Suicide Decedents by Method of Suicide, Colorado, 2004-2009.

	Firearm (%)	Hanging/strangulation (%)	Total (%)
Drug presence			
Antidepressants			
Percent positive	5.1	6.4	5.5
Not tested or missing	36.2	33.7	35.8
Opiates			
Percent positive	5.9	3.3	5.1
Not tested or missing	31.7	27.1	30.3
Cocaine			
Percent positive	3.4	6.6	4.4
Not tested or missing	31.7	31.9	30.4
Marijuana			
Percent positive	5.9	7.8	6.5
Not tested or missing	35.2	31.9	34.2
Amphetamines			
Percent positive	3.3	4.9	3.8
Not tested or missing	34.2	29.1	32.6
Demographic characteristics			
Gender			
Male	87.4	80.2	85.2
Age			
18-24	11.0	20.2	13.8
25-44	31.7	46.5	36.2
44-64	39.0	27.8	35.6
65+	18.4	5.5	14.4
Race/ethnicity			
Non-White	12.1	25.5	16.2
Educational attainment			
High school or greater	88.6	80.3	84.3
Marital status			
Married	40.5	31.0	37.6
Never married	28.6	43.6	33.2
Divorced	23.0	21.6	22.6
Widowed	7.5	3.2	6.2
Missing marital status	0.4	0.7	0.5
n	2,355	1,034	3,389

Source. Derived from COVDRS (Colorado Department of Public Health and Environment 2014).

drugs were much more likely to use a firearm. Conversely, those with a high school education or more who tested positive for cocaine were more likely to use hanging than firearms. For ease of interpretation, Figure 1 graphically illustrates the interaction effects. In this figure, it is clear that not being on opiates is strongly associated with hanging for those with less than a high school education, whereas the gap is much smaller for those with greater than a high school education. In sum, education is a significant moderator between drug use and method of violent suicide.

Discussion

Whereas previous research has established drug abuse as a major risk factor for suicide, this study is one of the first to show that drug use before suicide is associated with the selected

Table 2. Logistic Model of Drug Use and Odds Ratios of Suicide Method in Suicide Decedents, Colorado, 2004-2009.

	Article I. Hanging versus firearms[a]		
	OR	95% LL	95% UL
Drug presence			
Opiates (not present)			
Present	0.52	0.35	0.79
Not tested or missing	0.90	0.41	1.94
Antidepressants (not present)			
Present	1.45	1.04	2.03
Not tested or missing	0.99	0.64	1.52
Cocaine (not present)			
Present	1.30	0.90	1.88
Not tested or missing	0.99	0.47	2.11
Amphetamines (not present)			
Present	1.05	0.71	1.56
Not tested or missing	0.70	0.38	1.28
Marijuana (not present)			
Present	1.05	0.77	1.43
Not tested or missing	1.42	0.86	2.34
Demographic characteristics			
Gender (female)			
Male	0.56	0.45	0.69
Age (18-24)			
25-14	0.94	0.74	1.19
44-64	0.52	0.40	0.69
65+	0.25	0.17	0.37
Race/ethnicity (White)			
Non-White	1.78	1.45	2.18
Educational attainment (less than high school)			
High school or greater	0.59	0.47	0.73
Marital status (married)			
Never married	1.37	1.12	1.68
Divorced	1.28	1.04	1.58
Widowed/other category	0.97	0.63	1.50
Missing marital status	1.68	0.61	4.66

Source. Derived from COVDRS (Colorado Department of Public Health and Environment 2014).
Note. OR = odds ratio.
[a]Model also adjusts for missing values in drug results (referent in parentheses).

method of violent suicide and that these patterns vary by level of educational attainment. We find that the opiate use before death is associated with using firearms compared with hanging, whereas the use of antidepressants is associated with hanging compared with firearms. The model that includes the drug use covariates explains significantly more of the variance than a model that includes only demographic characteristics. In addition, we explored models where we summed the total number of drugs the decedent tested positive for; the results (not shown) were not significant. In other words, *specific* drugs rather than the number of drugs were associated with the selected method. We also find significant differences in the association between the drugs in predicting method of suicide by educational attainment. For those with less than a high school

Table 3. Logistic Model of Drug Use and Odds Ratios of Suicide Method in Suicide Decedents, Colorado, 2004-2009.

| | Hanging versus firearms[a] | | | | | | | | | | | | | |
| | Model 1: Opiates | | | Model 2: Antidepressants | | | Model 3: Cocaine | | | Model 4: Amphetamines | | | Model 5: Marijuana | | |
	b	95% LL	95% UL	*b*	95% LL	95% UL	*b*	95% LL	95% UL	*b*	95% LL	95% UL	*b*	95% LL	95% UL
Drug	−1.96	−3.23	−0.70	0.08	−1.02	1.18	−0.39	−1.10	0.31	−0.57	−1.34	0.19	0.40	−0.31	1.10
High school and above	−0.68	−0.94	−0.41	−0.66	−0.93	−0.38	−0.67	−0.94	−0.40	−0.67	−0.94	−0.39	−0.52	−0.80	−0.23
Drug × High school and above	1.58	0.24	2.92	0.28	−0.88	1.43	0.84	0.03	1.64	0.82	−0.06	1.70	−0.47	−1.25	0.31

[a]Models control for gander, age, race/ethnicity, marital status, and missing drug values.
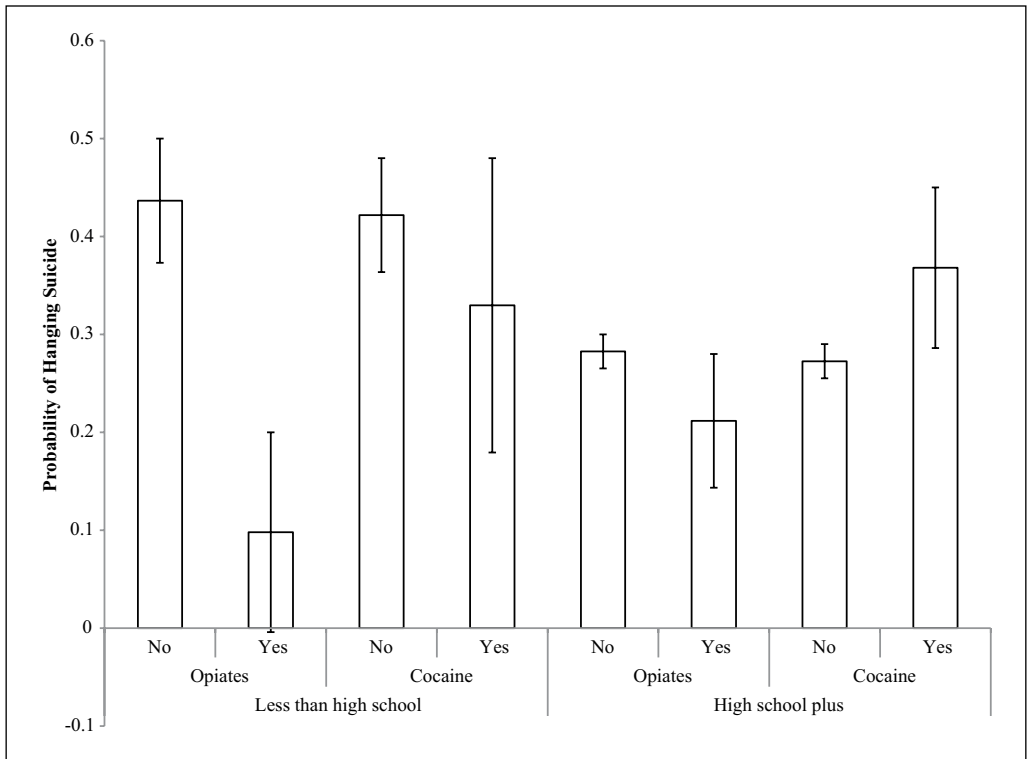
Figure 1. Predicted probability of hanging relative to firearms by presence of drug and educational attainment.

degree, opiates are strongly associated with using firearms compared with hanging, but the presence of opiates does little to differentiate the method of suicide among those with a high school degree or higher. In contrast, the presence of cocaine significantly increases the likelihood of hanging among those with higher levels of education but is not linked to method of suicide for those with less than a high school education. Compared with previous research that collapsed

firearms and hanging into a "violent" category (Dumais et al., 2005), our results suggest that firearms and hanging differ based on drug use and demographic factors.

While our work comports with previous research that illustrates that acute alcohol use is associated with method of suicide and that these relationships vary by demographic characteristics (Caetano et al., 2013; Conner et al., 2014; Kaplan et al., 2013), it remains unclear why there are associations between drug use and selected method of suicide. While we did not include adolescents in our study population, Goldston's (2004) excellent overview regarding substance use and suicide among adolescents offers some potential explanations of why certain drugs used before death may be associated with certain methods. Those who use drugs and commit suicide may experience tremendous stress, and the substance use may be taken as a means of escape. Similarly, drug use and suicide do not occur alone as they are also correlated with other risk behaviors, for example, weapon ownership. Furthermore, substance use may increase cogitations and diminish impulse control, potentially making suicide more likely. Future research must analyze why these drugs are associated with the specific methods and whether these associations are apparent in other contexts. While speculative, those who hang themselves may face longer term depression (thus the antidepressants), whereas those who shoot themselves may do so more impulsively (thus the opiates). Of course, this may not be the case for those who have suffered from long-term chronic pain that they treat with prescription pain killers. Clearly, more research is needed regarding the strong connection between drug use and suicide.

Drug use may not necessarily cause someone to select a specific method. Drug use may also precipitate a period of elevated risk of suicide or be taken in response to a critical situation (Hawton, 2005). Risk periods are relatively brief and once they are overcome, the likelihood of suicide drops (Hawton, 2005); therefore, a reduction in access to drugs during these critical times may reduce suicides, particularly if these drugs reduce inhibition. Drug use has been documented as a cause and consequence of impulsive behavior (de Wit, 2009). Those who self-select into using similar drugs in the critical periods immediately before suicide may also be more prone to using specific methods, which would make targeted interventions focusing on these users more effective. Because of the association between drug use and method of suicide, limiting drug use may lead to fewer suicides. In particular, gun owners with low levels of education who use opiates may be considered worthy of means restriction counseling to reduce their suicide rates (Bryan, Stone, & Rudd, 2011). In addition, reducing drug use may have differential impacts on suicide rates by level of educational attainment (Conner et al., 2014).

There are substantial and important distinctions between our analyses of decedents and analyses of the risk of death, including differences with the questions that can be addressed, the data that are analyzed, and the results that can be drawn. A major strength of this article is the detailed data set that provides toxicology reports of drug presence at the time of death over the course of a 6-year period among all suicide decedents in Colorado. A separate research question could instead examine the risk of death by, say, linking survey or census records to death records, which would enable estimates of the association between drug use at the time of the survey and subsequent death. Such research would require expensive and logistically complicated collection of toxicology reports at the time of the survey. But drug use at the time of the survey may not reflect regular use, may be biased downward (because heavy drug users may be missed by surveys and many interviewees may curtail their drug use before agreeing to drug testing), and may differ radically from drug use at the time of death (which might be atypical). Surveys can also collect self-reported drug use information, but such data will differ substantially from drug use at the time of death. Thus, the analyses of rich and detail decedent information provide advantages absent in other types of data collection.

Limitations

We identify four limitations to this investigation. First, decedents who use violent methods differ from those who use less violent methods; for example, they are more likely to be male (Denning,

Conwell, King, & Cox, 2000). Second, toxicologists did not test every suicide decedent for every drug used. However, in ancillary analyses, controlling for demographic factors, we found no significant difference in testing between methods, giving us confidence that our results are not driven by selective testing between methods. Thus, we find no evidence for a consistent bias in testing between methods. Still, the missing data may mean we are *underestimating* the prevalence levels. For example, other research has asserted that in some studies, more than 60% of all suicide decedents are not tested for alcohol (Cherpitel, Borges, & Wilcox, 2004). One potential way to overcome these underestimates would be mandatory statewide testing for all suicides; however, this data set may include the most complete set of drug tests of decedents extant, especially if potential budget cuts further restrict funds in state coroner systems. Third, firearms are slightly more lethal than hanging. Shenassa and associates (2013) found that firearms are about 4% more lethal than hanging among adults who were hospitalized for their suicide attempt. Other research corroborates that firearms are more lethal than hanging but notes that lethality differs by the type of firearm and the location of the gunshot wound (Rhyne, Templer, Brown, & Peters, 1995). Because the higher lethality of firearms could lead to some issues with selection (Hernán, Hernández-Díaz, & Robins, 2004), we ran auxiliary analyses to examine any potential bias. If we assume that the probability of death for those who were on antidepressants and used hanging is 0.9 (the overall estimate of the lethality of hanging produced by Rhyne and colleagues, 1995, and more conservative than Shenassa et al., 2013), the probability of a successful suicide for those without antidepressants who use firearms would have to be as low as 0.62 for us to observe an odds ratio of 1.45 (which we observed for antidepressants). Rhyne et al. (1995) and Shenassa et al. (2013) both estimated that the probability of mortality when using a firearm is above 90%, regardless of type of firearm or location of wound. Thus, the selection of methods could influence but is unlikely to drive our results. Finally, testing criteria and cutoffs may differ from state to state and country to country, which will affect the generalizability of our results (Kuhns, Wilson, Maguire, Ainsworth, & Clodfelter, 2009).

Conclusion

Despite these limitations, this is one of the first articles to show that drug use at the time of death is a significantly associated with the selected suicide method among the two leading methods. This study has illustrated that it is not only critical to examine how drug use is associated with method of suicide but how suicide method can even more accurately be understood with an interaction between suicide method and educational attainment. The interaction between education and the presence of drugs reinforces the notion that suicide is characterized with both individual and environmental risks. Because of our use of toxicological reports from an entire state, we are able to overcome data limitations of previous research that has analyzed the associations between self-reports of drug use and suicide. Previous research illustrates the importance of contextual factors, availability of fatal method, demographic factors, and personality traits in determining the method of suicide. To further elucidate the etiology of suicide, we suggest that future researchers investigate how contextual circumstances and drug use, and personal impulsivity, interact with the selected method and how these situations and drug use interact with demographic factors. The NVDRS would allow such analyses. A greater focus on the method, drug use, and demographic factors relating to suicide could allow policymakers to develop more specific policies to mitigate America's distressingly high suicide rates. Specifically, policies that take into account the complex interactions among drug use, educational attainment, and method may be best equipped to slow or even reverse the increase in suicide rates.

Authors' Note

of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of NIH, NICHD, the Colorado Department of Public Health and Environment, or the Centers for Disease Control and Prevention.

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