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Toxicology and Circumstances of Completed Suicide by Means Other than Overdose*

ABSTRACT: To determine the prevalence and circumstances of psychoactive substances amongst nonoverdose completed suicide, 1436 consecutive cases autopsied at the NSW Department of Forensic Medicine over the period 1/1/1997–12/31/2006 were analyzed. Substances were detected in 67.2% of cases, and illicit drugs in 20.1%. Alcohol was present in 40.6% of cases. Males were more likely to be positive for alcohol, cannabis, and psychostimulants, and females for pharmaceuticals. Illicits were associated with younger age. Alcohol was most prominent amongst toxicity cases, as were opioids, psychostimulants amongst gunshot cases, and pharmaceuticals amongst drownings. Cases in which drug and alcohol histories were noted were more likely to have a substance detected. Alcohol was more common where a suicide note was left and where relationship problems were involved. Pharmaceuticals were more common where a previous attempt was noted. Licit and illicit substances are strongly associated with suicide, even when the method does not involve drug overdose.

KEYWORDS: forensic science, suicide, toxicology, illicit drugs, alcohol, pharmaceuticals

Suicide is a leading cause of death worldwide, with approximately a million such deaths per year (1). It is estimated by the World Health Organization that this figure will reach more than 1.5 million per annum by 2020, a rate of one every 20 sec (1). There are also estimated to be between 10 and 20 attempts for each completion (2), with the lifetime prevalence of attempted suicide in the general population ranging between 3–5%, with a 12-month prevalence of 0.5% (3,4).

Suicide risk factors fall into five broad areas: (i) demographic characteristics (e.g., gender, previous attempts), (ii) psychopathology (e.g., Major Depression, Borderline Personality Disorder), (iii) family dysfunction (e.g., childhood abuse), (iv) social isolation/dysfunction (e.g., unemployment, homelessness), and, of interest here, (v) substance dependence (4–7). With the exception of gender (females are three times more likely to attempt suicide and males are three times more likely to complete), the risk factors for attempted and completed suicide are essentially the same.

What stands out from the first four groups of risk factors is that they are almost a redescription of the fifth (substance dependent populations). Dependent substance users have an extremely high prevalence of all of these risk factors when compared to the general population (7,8). Consistent with this, the relative risk of completed suicide by those dependent across a range of drugs is significantly higher than that of the general population: opioids

(14 times), cannabis (4 times), benzodiazepines (45 times), alcohol (6 times) (6,9).

Despite the known suicide risk to substance users, relatively few studies have examined the prevalence of psychoactive substances amongst completed suicides (10–15). Consistent with the risk factors for suicide, these studies report high rates of psychoactive substances amongst cases, with alcohol and pharmaceuticals (antidepressants, benzodiazepines) the most commonly detected drug types. Even fewer studies have attempted to examine the relationship between substances and the circumstances surrounding death (14,15). This is clearly crucial in understanding the dynamics of drug use and suicide. Our knowledge of the relationship between toxicology and suicide is also confounded by the fact that data are commonly aggregated across deliberate drug overdose and other methods.

The current study aimed to ascertain the prevalence of substances amongst cases of suicide by means other than psychoactive substance overdose. In this study, by definition, cases of deliberate overdose involve psychoactive substances. What is of interest here is how the presence of substances relates to other means of suicide. Specifically, the study aimed to:

1. Determine the prevalence of psychoactive substances amongst nonoverdose suicide cases over the period 1997–2006;
2. Determine the relationship between psychoactive substances and case demographic characteristics; and
3. Determine the relationship between psychoactive substances and circumstances of the fatal incident.

Methods

Case Identification

Autopsy reports and law enforcement summaries of all cases of completed suicide aged between 15 and 60 years who underwent autopsy at the New South Wales (NSW) Department of Forensic Medicine between January 1, 1997 and December 31, 2006 were

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retrieved. This age range was selected, as it represents the range that encompasses almost all illicit drug use (16). Cases where death was due to deliberate overdose by a psychoactive substance were excluded. The NSW Department of Forensic Medicine is located in central Sydney, and is the primary forensic pathology center in NSW, conducting approximately 2000 autopsies per year. Permission to inspect the files was received from the Sydney South West Area Health Service human research ethics committee. All cases were reviewed by the authors.

In NSW, a case must be reported to the Coroner where a person dies a violent or unnatural death. All such cases undergo a standardized forensic autopsy, with examination of all major organs and quantitative toxicological analysis. Cause of death is determined by the forensic pathologist on the basis of circumstances of death, the comprehensive autopsy findings, and the toxicological analyses.

Specific data retrieved from the autopsy and police reports included: cause of death, the demographic characteristics of victims, drug and alcohol histories, history of psychosis, the location where the fatal incident occurred, the time and date of the fatal incident, and the quantitative toxicological findings for each case. Toxicological data were reported for alcohol, cannabis (determined by the presence of Δ -9-THC and THC acid), morphine, methadone, methamphetamine, cocaine (determined by the presence of cocaine itself and/or the presence of benzoylecgonine), 3,4-methylenedioxy-methamphetamine (MDMA), benzodiazepines, gamma hydroxy butyrate (GHB), antidepressants, and antipsychotic medications. All presented toxicological analyses were of blood. Quantitative data are presented only for alcohol. In cases where there was prolonged hospitalization prior to death, antemortem toxicology was reported where available, otherwise toxicology was not reported. In all cases, drugs administered by hospital and medical staff were excluded.

Statistical Analyses

Where distributions were highly skewed, medians and inter-quartile ranges (IQR) were reported, otherwise means were presented. For bivariate comparisons, *t*-tests or odds ratios (OR) with 95% confidence interval (CI) were reported. For analysis of nondichotomous categorical variables, chi-square analyses were conducted. Mantel-Haenszel tests were used to determine trends across the study period. All analyses were conducted using *SPSS* for Windows (release 14.0) (17).

Results

Cases

A total of 1436 cases were identified. The mean age of decedents was 36.5 years (SD 11.5, range 15–60 years) and 81.5% were male, with no significant gender difference in age. Deaths were attributed to: hanging (54.5%), multiple injuries after fall from a height (15.3%), gas (12.4%), gunshot (4.6%), lacerations (3.4%), multiple injuries from vehicles (2.9%), immersion (2.9%), asphyxiation by means other than hanging (2.1%), electrocution (0.7%), burns (1.1%), and poison (0.9%). Multiple causes were identified in 0.6% of cases.

A history of substance dependence was noted in 16.9% of cases, injecting drug use in 8.6%, and alcoholism in 5.8%. Males were more likely to have histories of any substance dependence (18.3% vs. 10.5%, OR 1.90, CI 1.25–2.89), injecting drug use (9.3% vs. 5.3%, OR 1.85, CI 1.04–3.28), and alcoholism (6.6% vs. 2.3%, OR 3.05, CI 1.32–7.089).

Circumstances of Fatal Incident

The most frequent location was a home (61.1%), with cliffs (6.8%), the street (4.9%), and bushland (3.6%) the next most common. A suicide note was found in 32.2% of cases, with no gender difference. A previous attempt was noted in 19.8% of cases, with males less likely to have previous attempts reported (18.8% vs. 24.4%, OR 0.72, CI 0.52–0.98). A history of psychosis was noted in 15.0% of cases, and was less likely amongst males (13.4% vs. 22.2%, OR 0.54, CI 0.39–0.76). Relationship problems were noted as significant factors in 22.7% of cases, with no gender difference.

Cases were evenly distributed across the week, but not across diurnal periods ($\chi^2_3 = 12.4$, $p < 0.01$): 0001–0600 h (26.5%), 0601–1200 h (23.6%), 1201–1800 h (28.5%), 1801–2400 h (21.4%).

Toxicology

Toxicology was available for 1415 (98.5%) cases. Substances were detected in two-thirds of cases, and multiple substances in a quarter (Table 1). Illicit drugs were detected in a fifth of cases, and multiple illicit drugs in a twentieth.

The most commonly detected substance was alcohol (Table 1), with a median blood concentration of 0.10 g/100 mL (IQR 0.13, range 0.01–0.40 g/100 mL) among alcohol positive cases. The next most commonly detected substances were pharmaceuticals (antidepressants, antipsychotics, and benzodiazepines). The most common illicit was cannabis. In 7.8% of cases Δ -9-THC was detected, indicating active influence of the drug at the time of death. A further 2.7% had THC acid detected in the absence of Δ -9-THC, indicating recent consumption. Opioids (most commonly morphine) and psychostimulants (predominantly methamphetamine) were present in substantial minorities.

TABLE 1—Toxicology of nonoverdose suicide cases, 1997–2006.

	Males (n = 1151) %	Females (n = 264) %	All (n = 1415) %	Gender Comparisons
Global				
Substance detected	67.5	65.5	67.2	Not significant
Multiple substances	25.2	30.3	26.1	Not significant
Illicit drug(s) detected	21.2	15.5	20.1	OR 1.46 (CI 1.02–2.10)
Multiple illicit drugs	4.7	1.9	4.2	OR 2.55 (CI 1.01–6.44)
Alcohol	43.8	26.9	40.6	OR 2.12 (CI 1.58–2.85)
Cannabis	11.4	6.4	10.5	OR 1.87 (CI 1.11–3.15)
Δ -9-THC	8.4	5.3	7.8	
THC acid	9.0	4.9	8.3	
Opioids	9.2	9.5	9.3	Not significant
Morphine	5.6	6.4	5.7	
Methadone	2.1	1.5	2.0	
Codeine	5.7	4.5	5.5	
Psychostimulants	7.3	3.0	6.5	OR 2.52 (CI 1.20–5.27)
Methamphetamine	4.4	1.9	4.0	
Cocaine/ benzoylecgonine	2.2	0.0	1.8	
MDMA	1.4	1.5	1.4	
Pharmaceuticals	22.9	42.0	26.5	OR 0.41 (CI 0.31–0.54)
Antidepressants	9.9	23.5	12.5	OR 0.36 (CI 0.25–0.51)
Antipsychotics	3.9	10.6	5.2	OR 0.34 (CI 0.21–0.56)
Benzodiazepines	13.2	23.1	15.1	OR 0.51 (CI 0.36–0.71)

Note: Referent group = Females.

There were significant increases across years in the proportions of cases positive for cannabis ($\chi^2_1 = 4.7$, $p < 0.05$) and psychostimulants ($\chi^2_1 = 9.6$, $p < 0.01$). Amongst 1997 cases, 6.6% were positive cannabis, compared to 12.8% in 2006. Similarly, the proportion of psychostimulant positive cases increased from 3.8% to 12.0%. Amongst pharmaceutical substances, there were significant increases in antidepressants (1997: 8.8%, 2006: 15.2%; $\chi^2_1 = 11.1$, $p < 0.001$).

Toxicology and Demographic Characteristics—Males were significantly more likely to have an illicit, and multiple illicit, detected (Table 1). Specifically, males were more likely to be positive for alcohol, cannabis, and psychostimulants. In contrast, females were more likely to have pharmaceuticals detected, being more likely to be positive for antidepressants, antipsychotics, and benzodiazepines.

While there was no relationship between age and likelihood of a substance being detected, illicit substances were significantly associated with younger age, with each extra year associated with a 5% decrease in the likelihood of an illicit being present (OR 0.95, CI 0.94–0.97). Younger age was associated with testing positive for cannabis (OR 0.95, CI 0.93–0.96) and psychostimulants (OR 0.96, CI 0.94–0.98). In contrast, older age was associated with a higher likelihood of testing positive for pharmaceuticals: antidepressants (OR 1.02, CI 1.01–1.03), benzodiazepines (OR 1.02, CI 1.01–1.04).

Cases in which a drug and alcohol history was noted were significantly more likely to have a substance (89.8% vs. 62.6%, OR 5.34, CI 3.44–8.27), an illicit (50.6% vs. 13.9%, OR 6.33, CI 4.78–8.56), and/or alcohol detected (49.4% vs. 38.9%, OR 1.53, CI 1.16–2.03). More specifically, the cases with a history of injecting drug use were significantly more likely to have a substance (93.5% vs. 64.7%, OR 7.86, CI 3.80–16.24) and illicit drugs (69.1% vs. 15.5%, OR 12.21, CI 8.10–18.42) detected, but were no more likely to have alcohol present (41.5% vs. 40.6%). Cases where alcoholism was noted were significantly more likely to have

a substance detected (87.5% vs. 65.9%, OR 3.60, CI 1.85–7.08) and alcohol present (75.3% vs. 38.5%, OR 4.87, CI 2.90–8.16), but were no more likely to have an illicit drug present (14.8% vs. 20.5%). Amongst alcohol positive cases, those with a history of alcoholism had a significantly higher median BAC than other alcohol positive cases (0.16 vs. 0.10 g/100 mL, $U = 10047.5$, $p < 0.001$).

Toxicology and Circumstances of Incident—There were notable differences between suicide methods and detected drugs (Table 2). Whilst prevalent across all methods, the presence of substances varied across methods ($\chi^2_6 = 22.0$, $p < 0.001$), being almost universal in drowning cases. By contrast, the presence of illicit substances did not vary.

In terms of individual drug classes, alcohol varied significantly across methods ($\chi^2_6 = 43.4$, $p < 0.001$), and was most prominent amongst toxicity (gas, poison) cases (OR 1.81, CI 1.32–2.48). Opioids also varied by method ($\chi^2_6 = 13.1$, $p < 0.05$), and were significantly higher amongst toxicity cases (OR 2.20, CI 1.41–3.44). Similarly, psychostimulants varied by method ($\chi^2_6 = 13.7$, $p < 0.05$), and were higher amongst gunshot cases (OR 3.04, CI 1.49–6.21). Finally, pharmaceuticals varied across methods ($\chi^2_6 = 14.2$, $p < 0.05$), being higher amongst drowning cases (OR 2.56, CI 1.31–4.97). Specifically, drowning cases were more likely to have benzodiazepines (OR 2.56, CI 1.24–5.29) and antidepressants (OR 3.23, CI 1.56–6.69) detected. In contrast, the proportion of cannabis positive cases did not vary by method.

Cases where notes were left were more likely to have alcohol (OR 1.41, CI 1.12–1.77) and less likely to have cannabis (OR 0.66, CI 0.44–0.97) present (Table 2). Cases in which relationship problems were prominent in the suicide were more likely to have alcohol present (OR 1.60, CI 1.25–2.06), but less likely to have tested positive for pharmaceuticals (OR 0.50, CI 0.36–0.69).

Pharmaceuticals were more than twice as likely to be detected where a previous attempt was noted (OR 2.61, OR 1.98–3.43).

TABLE 2—Toxicology of suicide cases by circumstance of incident.

Circumstance	Drug Class						
	Substance %	Illicit %	Alcohol %	Cannabis %	Opioids %	Psychostimulants %	Pharmaceuticals %
Method							
Hanging/asphyxia	66.4	19.2	42.8	10.1	7.7	6.7	24.0
Jump (height/train)	62.5	20.5	30.9	12.0	8.5	5.4	29.7
Toxicity (gas, substance)	74.6	21.2	53.4	9.5	15.3	4.2	26.5
Gunshot	67.7	29.0	29.0	12.9	12.9	16.1	24.0
Sharp object injury (cuts and stabs)	53.2	19.1	14.9	12.8	12.8	2.1	34.0
Electrocution/burns	75.0	20.0	35.9	10.0	10.0	10.0	35.0
Drowning	91.7	19.4	52.8	5.6	5.6	8.3	47.2
Suicide note							
Yes	67.6	19.6	46.2	8.0	10.9	7.1	26.7
No	66.7	20.6	37.9	11.7	8.4	6.3	26.0
Relationship related							
Yes	69.2	21.1	49.7	11.3	8.2	8.2	17.0
No	66.4	19.8	38.1	10.3	9.4	6.0	29.1
Previous attempt							
Yes	77.0	23.0	43.5	10.6	10.2	8.1	42.9
No	64.7	19.4	39.9	10.4	9.0	6.1	22.4
Psychosis							
Yes	62.2	17.2	22.0	11.3	8.6	4.8	43.8
No	67.9	20.6	43.4	10.3	9.4	6.8	23.9
Time of day							
0001–0600	75.1	24.2	49.5	10.9	11.9	10.2	25.3
0601–1200	52.6	17.0	19.1	8.7	8.3	6.1	29.6
1201–1800	60.7	21.8	30.0	13.2	10.2	5.3	29.4
1801–2400	76.1	24.9	51.4	14.6	8.3	7.1	25.5

Such cases were more likely to have antidepressants (OR 3.01, CI 2.15–4.22), benzodiazepines (OR 2.21, CI 1.60–3.06), and antipsychotics (OR 2.05, CI 1.24–3.41) present.

Amongst cases where psychosis was noted, 34.9% were positive for antipsychotic medications. They were far less likely to have alcohol detected (OR 0.37, CI 0.26–0.52). The excess of pharmaceuticals amongst these cases (OR 3.50, CI 2.59–4.75) was entirely due to antipsychotic medications.

There were no significant variations across days of the week in the proportion that tested positive for a substance, an illicit, or any specific drug. There was a significant diurnal difference for substances being detected, being more common in the 0001–0600 h and 1801–2400 h periods ($\chi^2_3 = 44.2$, $p < 0.001$). There was no diurnal variation in the probability of illicit substances being detected (Table 2). The only drugs in which there were significant diurnal differences were alcohol ($\chi^2_3 = 78.2$, $p < 0.001$), substantially more common for incidents that occurred in the 0001–0600 h and 1801–2400 h periods, and antipsychotics ($\chi^2_3 = 13.9$, $p < 0.01$), most commonly detected in the 0601–1200 h period.

Discussion

The current study provides the most detailed examination of the toxicology of suicide by means other than overdose to be conducted to date. Consistent with earlier research (10–15), substances were ubiquitous. The proportions seen were far in excess of what would be expected amongst the general population, providing daily use as a proxy comparison: alcohol (8.9%), cannabis (1.9%), methamphetamine (0.4%), and heroin (0.14%) (16). These substances were present at 4.6 (alcohol), 5.6 (cannabis), 10.0 (methamphetamine), and 41.4 (heroin) times these levels in the general population. The extensive role of substances was further demonstrated by the fact that one in six cases was noted to have a history of drug and alcohol dependence, and one in ten was a known injecting drug user. What needs to be borne in mind when contemplating these figures is that the study explicitly excluded deaths from drug overdose. The findings are consistent with studies that indicate dependent drug users most commonly use suicide methods other than overdose (7).

Consistent with the epidemiology of substance use (16), alcohol and cannabis were the most commonly detected substances. The gender demographics were also consistent with population figures, and other studies of completed suicide (11,15). Opioids, however, provided a notable exception. Despite the predominance of male opioid users amongst opioid-using populations, female cases were as likely to have opioids present. This may well reflect the exigencies of the heroin-using lifestyle, and it is well documented that female death rates are as high as those of males amongst these groups (7). The relationship between younger age and illicit drugs is also consistent with population patterns (16).

There were notable differences in the prevalence of substances across methods of suicide. Of particular note was the relationship between psychostimulant use and gunshot death. Previously, a strong relationship between psychostimulants and homicide victims has been noted in studies in Australia and elsewhere (18,19). It should be noted that firearms ownership is heavily restricted in Australia, and gun ownership uncommon. This is reflected in methods of suicide, with hanging the most common method, accounting for 51% of cases nationally, with gunshot accounting for 7% (20). The increase in the prevalence of methamphetamine amongst cases across the study period is cause for concern, and reflected in the large increase in methamphetamine use seen in Australia since the late 1990s (21). Similarly, the increase in antidepressants is consistent with the

increase in prescribing of these drugs over recent decades (22). In contrast, the prevalence of cannabis increased across the period, despite the population prevalence declining (16).

Only a third of known psychotic cases had antipsychotic medications in their blood at the time of death. Furthermore, one in ten of these cases tested positive for cannabis and one in twenty for psychostimulants. The use of these substances may well have increased both psychotic symptoms and proximal suicide risk (23).

How then are we to understand the prevalence of substances amongst cases of nonoverdose suicide? The results of this, and other studies, reflects the high rates of psychopathology and the difficulties of the lives of substance-dependent individuals. That is, they reflect the continuing risk of suicide amongst groups with elevated levels of risk factors (7). The proximal effects of intoxication, however, must also be considered. Alcohol, for instance, was related to a number of circumstances surrounding death, and frequently occurred in high concentrations, suggesting a proximal role in many cases.

In summary, psychoactive substances played a significant role amongst both genders and across all circumstances. There were, however, notable variations in toxicology across genders and circumstance. Licit and illicit substances are strongly associated with suicide, even when the method does not involve deliberate drug overdose.

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