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Suicide by poisoning in New Zealand—a toxicological analysis

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Abstract

Aim Determine major substances and risk factors for suicide by chemical overdose in New Zealand between 2001 and 2005.

Method All intentional deaths between 2001 and 2005 were reviewed. Primary substances causing death were verified from toxicology reports.

Results The chemical suicide rate was higher among older Europeans, women and those in paid work than other groups. Carbon monoxide and tricyclic antidepressants (TCAs) continue to be the most common chemicals used, in spite of market changes. Anaesthetics and cyanide deaths among workers were noted.

Conclusion Restricted access to work-related chemicals and stricter prescription/dispensing controls for TCAs may reduce self-poisoning in New Zealand.

Suicide by chemical overdose in New Zealand has been said to be both increasing[1] and decreasing,[2] with this discrepancy explained at least in part by different definitions of these deaths. This paper utilised the Chemical Injury Surveillance System definition, which included inhalation or ingestion of chemicals and self-immolation or dousing with petrol or other hydrocarbons followed by lighting one's self on fire (Ministry of Health and the Institute for Environmental Science and Research, Ltd (ESR) as described in McDowell et al[1]).

This is the first New Zealand report of suicide deaths attributed to chemical substances where the presence of the suspected chemicals was verified by toxicologists with access to all records (including Pathology reports when applicable) reviewing detailed toxicology reports for each case.

Choice of method for committing suicide is influenced by availability of material.[3-7] Although little is known about risk factors for chemical suicide in New Zealand, intentional overdoses of tricyclic antidepressants (TCAs) are the most common fatal agent among prescription medicines in New Zealand.[1,8,9]

By looking at this specific suicide method it may be possible to identify a population at risk of using toxic materials. This population may differ significantly from those being targeted by the Suicide Prevention Strategy.[10] Verification of toxicology data may also provide new information on specific toxic substances requiring restricted access in New Zealand.

Methods

According to the 1988 Coroner's Act, all deaths in New Zealand "Without known cause, suicide or unnatural or violent" must be reported to the Coroner.

All deaths resulting from violent, unnatural, unexpected, or suspicious causes from January 2001 to November 2005 and given a final verdict by November 2005 were reviewed. Suicide deaths were those deemed "Intentional, with the intent of taking one's own life" by the Coroner.[11] Those determined by the coroner as "Unintentional or Undetermined" were not included.

Deaths where the main cause of death was non-chemical (for example by hanging and firearms, etc.) were used to compare with those that were caused by chemical over-exposure.

Chemical suicide is defined as any *suicide* resulting from over-exposure to a chemical. This includes carbon monoxide poisoning from car exhaust, overdose of therapeutic or recreational substances, ingestion of flammable liquids, solvents, pesticides or cyanide or self-immolation.

The primary substance causing each death was initially recorded from the conclusion of the ESR toxicology report as obtained through the Coronial file. When toxicological data was not available (such as a death resulting from flaming petrol), the primary substance was taken from the Coroner's ruling on cause of death. This study did not have access to decedents' prior medical or prescription histories. It does not include non-fatal suicide attempts. The data collection method has been described in more detail previously.[12]

Toxicology results for primary substance resulting in death were reviewed by an ESR toxicologist (D. Kappatos) and verified according to laboratory records. Incidents were defined as resulting from a primary substance (where the primary substance could be identified), from multiple chemicals (polydrug overdose) if these were identified or "substance not determined" if none was identified. Cases that could not be verified using toxicology data were excluded from further analysis in the specific substance part of this research.

Ethnicity was assigned in hierarchical order according to the Ministry of Health Ethnicity Data Protocol.[13] Persons identified in the coronial database with more than one ethnicity were classified hierarchically as Māori (if Māori was one of the ethnicities); Pacific Island; Asian; other groups (except New Zealand European); and New Zealand European.

Due to a time lag between events and completion of inquest/submission of records, some deaths occurring within this time period (approximately 11% according to ESR experience[1]) were likely to be absent. For this reason, age-standardised population rates were calculated for the three years 2001, 2002 and 2003. Population data for New Zealand was taken from the Census Year 2001, Usually Resident Population.[14]

SAS v9.1.3 software was used to compute statistics for comparison of chemical suicide rates by gender, age, ethnicity and employment category. The Cochran-Mantel-Haenszel correlation was used to derive relative risks. Significant differences between age groups was determined using a two-sample t-test for comparing means, while differences between genders, ethnicity and employment category were determined using the Pearson chi-square test for binomial proportions.

Stata v11.1 software was used to conduct multivariate logistic regression of binary outcomes (chemical versus other suicide methods). Age and gender differences by chemical category were analysed using one-way ANOVA and t-test for independent samples with unequal variance.

Results

During the period 2001–2003, suicide was the ninth most common cause of death in New Zealand, accounting for 2% of all deaths.[15] Among non-medical causes, suicide was second only to accidental injury, largely traffic accidents.

The Ministry of Justice Coronial Services Office reported all deaths to ESR from the period 2001 to November 2005, after the completion of investigations and determination of intent of the deceased. As of November 2005 there were 2261 deaths reported as suicide to ESR. Of these, approximately 10% (219 cases) occurred in the years prior to 2001—leaving a total of 2042 cases for the relevant period (see Table 1).

Table 1. All suicides in New Zealand 2001 to 2005 as recorded in November 2005

Study group	Cases N (%)	Average age (SD) Range	Waged (%)	Female (%)	Māori (%)
All cases occurring 2001 to 2005	2042 (100)	40.6 (17.9) 11–95	48.0	24.3	17.0
Deaths by non-chemical methods	1399 (69)	38.8a (18.0) 11–95	47.7	21.7	21.7d
Deaths by chemical methods	643 (31)	44.4 (17.2) 13–92	47.1	29.9	6.7
Carbon monoxide (CO) overdose	418 (20)	42.7b (16.4) 13-91	55.5c	20.4	7.2
Other chemical methods	225 (11)	47.7 (18.0) 14–92	35.6	47.6	5.8

a. Younger than victims using chemical methods, $p<0.0001$

b. Younger than victims using non-CO chemical methods, $p<0.001$

c. More likely to be waged than victims using non-CO chemical methods, $p<0.001$

d. More likely to be Maori than victims using chemical methods, $p<0.001$

Table 1 outlines characteristics of intentional deaths during this period. The majority (69%, 1399 cases) of suicides resulted from non-chemical methods such as hanging and firearms. The remaining 643 deaths, or 31% of total suicides, resulted from chemical methods, with carbon monoxide overdose being the most common.

Age—Victims who used chemical methods were five years older, on average, than those who used other methods. Age differences between chemical and non-chemical suicide were largest for Māori victims: 36 versus 29 years old, respectively ($p<0.0005$). Data for Pacific Island Peoples and Asian victims were too sparse to test for age differences by choice of modality.

Ethnicity—When broken down by ethnicity, age-standardised suicide rates based on complete data from 2001 to 2003 show that the chemical suicide rate is considerably higher among New Zealand Europeans than all other ethnic groups (Figure 1). The suicide rate for Māori using non-chemical methods is disproportionately high, accounting for one in five of all cases of non-chemical suicide. However, this is not reflected in self-poisoning suicides, where Māori cases represent one in fifteen cases.

Gender—Males outnumber females by 3:1 in all suicides. In chemical suicides, however, gender differences are more marked; carbon monoxide deaths are far more common for males than females (5:1) and non-carbon monoxide chemical deaths are nearly equal between males and females (118 males vs 107 females).

Logistic regression of chemical suicide versus non-chemical means—Among all suicides, the strongest association with using chemical methods was protective Māori ethnicity, representing a risk reduction of more than 3-fold odds. Being female was also significantly associated with chemical modality, with females 1.6 times more likely to use chemicals compared with males (see Table 2).

Figure 1. Age-standardised annual suicide rates for 2001–2003 by ethnicity, chemical versus non-chemical methods

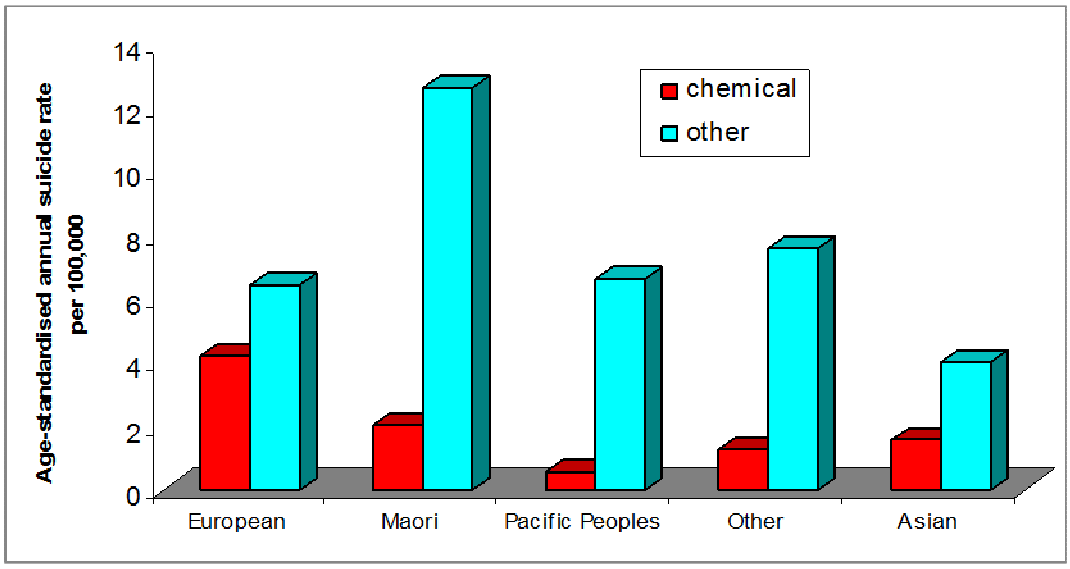

Table 2. Logistic regression of chemical versus non-chemical suicide N=2042

Variable	Odds Ratio (95% confidence interval)	P value
Māori ethnicity	0.31 (0.22 – 0.44)	0.0001
Waged employment	1.19 (0.97 – 1.45)	0.07
Female	1.64 (1.31 – 2.05)	0.0001
Age in years	1.01 (1.01 –1.02)	0.0001

Being in waged employment was positively related to chemical over-exposure *compared to* nonchemical suicide modalities in logistic regression, although this was not statistically significant. This is primarily due to the large representation of waged victims (56%) using carbon monoxide poisoning, compared to the 36% of victims using other chemical means who were employed at the time of death.

Specific substances not including carbon monoxide—One in 10 suicides (225/2042 cases) that occurred between 2001 and 2005 were the result of chemical overdose or self-immolation/burning (six events). Poisonings were the result of more than one substance in half of cases (51%) where two or more substances were detected. In approximately one in 10 cases (19 overall), more than one substance *contributed to the overall death:* these are listed as polydrug exposures in Table 3.

Table 3. Chemicals used in suicide events, 2001 to 2005

Category of chemical substance	Cases recorded from Coronial Database (N)	Average age of decedents (years)	Percent female (%)	Cases excluded after toxicology verification (N)
Antidepressants	69	41.1*	51%	1
Sedatives and relaxants	15	67.9*	73%*	2
Analgesics	44	49.6	50%	7
Other drugs	29	48.5	45%	2
Industrial substances	42	50.8	26%*	11
Polydrug overdoses	19	45.9	58%	2
Substances not determined	6	40.5	50%	4
Total	**225**	**47.7**	**48%**	**29**

*Statistically significant difference from all other categories using t-test for independent samples with unequal variance.

Table 3 above lists the chemical categories identified from Coronial files and later verified by ESR toxicology laboratory data for 225 chemical suicides. A total of 87% of coronial records were confirmed using toxicology data. In 29 cases, chemical suicides could not be verified and these are listed below:

- No toxicology data and no specific chemicals from the death scene (four cases)
- Paracetamol overdoses (five of six cases in this dataset) sometimes lack forensic toxicology tests because overdose is confirmed by blood test at hospital admission. Paracetamol overdose is typically prolonged with characteristic symptoms. Post-mortem pathology results of the deceased reveal paracetamol-induced liver damage as further confirmation of the cause of death, rather than post-mortem toxicology results.
- Evidence of specific chemicals found at the death scene is sometimes recorded without toxicology data for verification. In this dataset we encountered the following examples: intentional fire using hydrocarbon solvent (eight cases), multiple chemicals (two cases) and single cases each of amitriptyline, caustic soda, clonazepam, codeine, ethylene glycol, glyphosate, insulin, meprobamate, methamphetamine and morphine or heroin.

All 29 cases lacking toxicological verification were excluded from further analysis.

Antidepressants were the largest single category of non-carbon monoxide (non-CO) chemicals used for suicides, particularly TCAs, which accounted for 95% of all antidepressant suicides and 33% of all non-CO chemical suicides. People using antidepressants were younger on average (41 years of age) than all other people using non-CO chemicals (51 years of age).

As shown in Table 3, deaths involving sedatives and relaxants occurred among people who were older and more likely to be female, compared to all other categories of chemicals used. Conversely, those who used industrial chemicals were more likely to be male than all other chemical categories.

Table 4. Chemical suicide events verified for analysis after toxicology review

Category of chemical substance for analysis	Chemical	Recorded cases	Cases with toxicology evidence
Primary substance causing death			
Antidepressants	Tricyclics	65	64[a]
	Other	4	4
Sedatives and relaxants	Benzodiazepines	8	7[b]
	Meprobamate	1	0
	Zopiclone	6	6
Analgesics	Morphine	16	15
	Codeine	7	6
	Dextropropoxyphene	7	7
	Paracetamol	6	1
	Other	8	8[c]
Other drugs	Barbiturates	5	5[d]
	Insulin	6	5
	Other diabetic drugs	1	1
	Antipsychotics	1	1
	Anticonvulsants	3	3
	Anaesthetics	3	3
	Heart medication	4	4
	Quinine	1	1
	Methamphetamine	1	0
	Ethanol and Ethanol/methanol	4	4
Industrial substances	Etorphine	1	1
	Cyanide	10	10
	Ethylene glycol	4	3
	Herbicides/insecticides	8	7[e]
	Caustic soda	1	0
	Petrol then fire	6	6
	Hydrocarbon ingestion	2	0
	Hydrocarbon inhalation	2	2
	Hydrocarbons, no ESR record	8	0
Polydrug overdose		**19**	**17**
Substance not determined		**6**	**2**
Total		**225**	**196 (87%)**

a. includes amitriptyline(21), dothiepin(17), nortriptyline(13), doxepin(9), imipramine(3), clomipramine(1), trimipramine(1)

b. includes midazolam(1), triazolam(4), temazepam(1), temazepam and triazolam (1)

c. includes tramadol(2), methadone(2), orphenadrine(1), dihydrocodeine(1), pethidine(1), diphenhydramine (1)

d. includes quinalbarbitone(2), phenobarbitone(2), thiopentone(1)

e. includes paraquat(1), bendiocarb(1), glyphosate, the active ingredient in Roundup (3), boric acid (1), mevinphos (1)

Work-related chemicals—Although suicide deaths from work-related chemicals were uncommon in this dataset (the majority of chemicals were prescribed to the decedent), four anaesthetic technicians and one anaesthetist used work-related chemicals: propofol (2), pancuronium (1), thiopentone (1), and vecuronium (1). Four other suicides involved chemicals that were available through the individual's occupation: cyanide (2), bendiocarb (1), and the veterinary sedative etorphine (1).

Discussion

This is the first New Zealand report of chemical suicide data that has been verified by a toxicologist with access to the original toxicology data. We found that specific substances recorded in Coronial files (excluding carbon monoxide) were consistent with toxicology results in 87% of cases. Incidents unable to be verified resulted mainly from lack of toxicology samples. These were suicide deaths where the substance in use had been verified from other means such as burning with petrol, paracetamol ingestion or other substances found at the scene of death.

Ethnicity data were not self-reported in this research, and as such may have resulted in an under-representation of Māori victims. However, this potential bias applies equally to victims dying from non-chemical and chemical exposures, so has not significantly impacted results.

Ethnicity, gender, occupational status and age were significant influences on the modality of chemical suicide in New Zealand. Although ethnic differences in choice of method may be the result of unknown cultural factors, there are some consistencies with Alaskan Native Peoples, who have a higher overall suicide rate than the non-Native population but a lower chemical suicide rate than non-Natives.[16]

At least some of the ethnic differences in the rates of chemical suicide could be explained by differences in prescribing of antidepressants in New Zealand; prescription rates for antidepressants are approximately two times higher for people of New Zealand European or Other ethnicity compared with Māori ethnicity, and approximately three times higher than that for Pacific Island people.[17]

The subpopulation of non-CO chemical suicide victims in New Zealand can be described as disproportionately unemployed, European and female *compared to victims of all other suicide methods*. National suicide prevention programs are focused on populations at the greatest risk of overall suicide, who are younger and more likely to be Māori. Specific prevention efforts for overdoses of TCAs in particular, could be targeted at improved prescription patterns and greater physician awareness of the toxicity of TCAs.

Easy access to, and lethality of methods are two of the major influences on whether or not such modes will be used in suicide.[5] Of the nine incidents using work-related chemicals in this study, anaesthetists and anaesthetic technicians were the largest single group, a phenomenon that has been noted overseas[18,19]. Cyanide was the most common single industrial substance used in New Zealand chemical suicides (ten in this dataset).

Trends in poisoning as a suicide modality—There was no evidence of a continued decrease in the proportion of suicides by chemical poisoning and carbon monoxide in New Zealand from the 1990s to the early 2000s as was observed in Australia for the same period.[20] In this dataset the proportion of suicides using chemicals (excluding CO and self-immolation) was 11%, up from less than one in 10 suicides in 1999. Drug-related poisoning increased among women aged 15 to 44 years over the same period in England and Wales, while decreasing among all other age groups[21]. Unfortunately, it is not possible to examine age-group trends in the current dataset because of insufficient numbers for each age-group.

More than 40% of suicide events among women in UK over the same time period occurred as a result of ingesting chemicals (excluding CO and self-immolation)[22,23] compared to 20% of female suicides in New Zealand. The most common chemicals used in UK suicides in 2001 were Coproxamol (combined dextropropoxephene and paracetamol, a total of seven events in the New Zealand dataset) followed by TCAs, a total of 64 events in this dataset.[21,24] Both New Zealand and UK have since withdrawn propoxyphene and dextropropoxyphene from their markets.

Toxicity of TCAs—Antidepressant overdoses using TCAs remain the most common suicide poison used in New Zealand. The combination of easy access to, and the toxicity of TCAs has resulted in continued deaths from overdoses of these drugs, as repeatedly noted in New Zealand[1,8,9,17] and internationally.

Reith et al[9] reported that the number of New Zealand deaths per prescription for TCAs was 30 times higher than that for Selective Serotonin Reuptake Inhibitors (SSRIs), similar to the 10-30 fold increased suicide mortality risk with TCAs compared to SSRIs reported in the UK.[23,28] A study in the United States (US) comparing prescribing rates by geographical areas found that TCA prescribing was significantly associated with increased suicide rates.[29]

In the current study, the TCAs remain over-represented, accounting for 33% of all non-CO chemical suicides and 94% of all antidepressant suicides over the five-year period (percentages are not directly comparable in these four national studies due to varying data collection methods).

Morgan[8] identified a total of 42 TCA fatal overdoses in New Zealand between 1998 and 2001, including those of accidental or unknown intent. This equalled 10.5 TCA deaths (suicide and others) per year, compared to 13 TCA suicide deaths per year in the current research, counting only one category of deaths (those deemed *intentional* by Coronial verdict). Had deaths with *undetermined intent* according to Coronial verdict been included in this analysis, the death rate using TCAs would have been higher.

With the introduction of newer, less toxic antidepressants (specifically the SSRIs) it was hoped that the number of fatalities per overall antidepressant dose would decline, as reported in the US[30], Austria[31] and the UK[32], if not the Nordic countries.[33] Notwithstanding, TCAs continued to dominate the number of completed suicides and ICU admissions from antidepressant overdoses in the US,[29] Finland[34] and the Netherlands.[35] This is despite the fact that overdoses of other antidepressants were far more common; 70,597 compared to 12,025 overdoses of TCAs in one region of the US.[36] Further research focusing on TCA and other antidepressant prescription rates over the study period and to the present time would be helpful.

Prescription patterns for antidepressants in New Zealand—Between 2004 and 2007, women over 65 were more likely to be prescribed TCAs than SSRIs in New Zealand, while men in this age group were equally likely to be prescribed SSRIs or TCAs.[17] Morgan[8] found that 95% of suicide deaths from TCA overdose between 1998 and 2001 in New Zealand were prescribed the TCA at the time of death.

Prescription rates for TCAs have not declined in New Zealand;[37] indeed, they have been on the increase since 2003.[38] This presumably reflects the widening list of

indications for use of TCAs including anxiety, attention deficit disorder, management of chronic pain and as an alternative hypnotic to benzodiazepines.[39]

New uses of TCAs may be obscuring historical warnings associated with this class of chemicals and this should be considered in revisions of prescribing and treatment guidelines, particularly for these newer indications. Prescriptions for this class of chemicals, and we would argue the associated risks of death by suicide, are not expected to decrease without a significant change in practice to more carefully consider the need for a TCA rather than an alternative treatment.

Restricting ease of access to lethal exhaust emissions and industrial chemicals— Deaths from carbon monoxide poisoning, largely from car exhausts, account for almost two thirds of poisoning deaths in New Zealand. At some 80 deaths per year, this is equivalent to one fifth of the 2009 road toll.[40]

Given the attention paid to efforts to reduce the latter, it seems extraordinary that the well recognised range of options to reduce the lethality of vehicle exhaust emissions have yet to be implemented (including catalytic converters, automatic idling devices, modifying exhaust pipes so they are not compatible with hoses and carbon monoxide sensors inside cars to stop the motor from running when life-threatening concentrations are reached).

Regulations in the UK to require catalytic converters were associated with a subsequent decrease in suicide deaths using this method).[20]

Deaths due to overdose of chemicals presumptively obtained from the workplace (particularly cyanide and anaesthetic drugs) is also of concern and in our opinion would justify a review of the effectiveness of current regulations regarding access to these agents.

Chemical poisoning remains a major cause of death in New Zealand. This review identifies three groups of chemicals where changes in car safety regulations, prescribing of antidepressants and control of particularly dangerous workplace chemicals have the potential to reduce the number of deaths from such poisoning.

Competing interests: None known.

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