Surveillance of suicide deaths involving gases in Australia using the National Coronial Information System, 2006 to 2017

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Abstract

Background: There have been concerns about the increased use of helium and nitrogen gas as a suicide mechanism in Australia.

Methods: National Coronial Information System data were used to investigate gas-specific suicides in Australia over the period 2006–2017. Characteristics were compared between helium or nitrogen, carbon monoxide and seven other gases.

Results: Gas inhalation accounted for 10% (3,103/31,002) of all suicide deaths in Australia between 2006 and 2017. The mean age of individuals who died by suicide was 47.6 years (SD 16.9, R 14-97) and 83.3% were male. The number of gas suicides declined over the study period (IRR=0.96). The fall was associated with a 47% decline in carbon monoxide suicides (IRR=0.93). There was an increase in deaths due to argon (IRR=1.60) and nitrogen (IRR=1.27). Compared to individuals using other non-carbon monoxide gases, individuals who died by suicide from helium or nitrogen were significantly more likely to be older, have a physical illness and/or disability, have contacted a euthanasia group and have accessed instructional material and purchased gas online.

Conclusions: Suicides by carbon monoxide decreased between 2006 and 2017 alongside an increase in argon and nitrogen gas use – particularly among older adults. The ease of access to these gases points to new targets for means restriction.

Implications for public health: Identifying the types of gases used in suicide deaths and emerging trends may enable targeted interventions that could potentially reduce access.

Key words: suicide, surveillance, epidemiology, public health

Globally, there have been substantial changes in the types of gas used as a suicide mechanism in the past 20 years.[1] Previous research has shown a decline in the number of suicide deaths using carbon monoxide (CO) gas both in Australia[2] and internationally,[1,3] as well as increases in the number of helium suicide deaths across Australia,[4] the UK,[1] the US[5] and Hong Kong.[6] There have also been reported increases in the number of nitrogen suicide deaths in Australia.[7] The increase in helium gas suicide deaths, to some extent, has been linked to the availability of online references to this suicide methodology.[1,6] Helium and nitrogen gas asphyxia is also referenced by euthanasia advocacy groups, both in print[8] and online,[9] with such groups emphasising the increased lethality and undetectability of the gases in routine blood-gas analysis, compared to other gases. The free availability of such material to highly vulnerable individuals is of great concern to public health.

The surveillance of specific types of gas used in suicide is problematic using data systems that are reliant on the International Classification of Diseases 10th edition (ICD-10) coding.[3] Presently, there are no subcategories for 'X67: intentional self-poisoning by and exposure to other gases and vapours' available to distinguish between gases. Therefore, gases are reported together within cause of death statistics[10] and specific trends in gases are relatively unknown. An alternative to ICD-10 coding, coronial cause of death and abstractor narrative text fields, has been effective within the US National Violent Death Reporting System (NVDRS) to isolate and report gas suicide trends in CO, helium, hydrogen sulphide, nitrogen, nitrous oxide, propane and natural gas.[3] Incident narrative text fields were shown to have a sensitivity of 91% to detect specific gas types.

In Australia, suicide mortality data are available for research purposes through the National Coronial Information System (NCIS), a secure database of information on deaths reported to a coroner.[4] Each NCIS case contains ICD-10 codes, demographic information, coded 'mechanism of injury' and 'object or substance', as well as non-coded data detailing the circumstances of each death available through coronial, autopsy, toxicology and police reports. NCIS mechanism of injury codes, object or substance codes and toxicological reports have been used in Australia to determine the characteristics, manner and circumstances of methamphetamine-related suicide.[11] NCIS data have also been used in two epidemiological studies of suicide deaths involving gases.[4,7] The first of these was a report by the Australian Competition and

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Consumer Commission (ACCC) that examined helium gas asphyxia suicides over the period of July 2000 to December 2016 and found a significant increase in helium suicide deaths during this period.[4] A South Australian study[7] also identified increases in suicides by helium and nitrogen gas between January 2003 to December 2017, noting that nitrogen use may surpass helium in gas asphyxia suicide deaths. To date, no Australian studies have investigated trends in multiple gases used in suicide at a national level. The monitoring of gases in suicides could present new opportunities for public safety activities to reduce suicide deaths.

While CO has, historically, been the target of mean restriction efforts, such as removal of CO from domestic gas, there is evidence that the decrease in CO-related suicides has been accompanied by an increase in other gases, such as helium[3] and nitrogen.[7] Changing trends in gas usage as part of suicide attempts warrants attention, as means restriction efforts may need to be refocused to deal with the uptake of other, potentially more accessible, gases. As there is, however, a paucity of research to confirm that other gases such as helium and nitrogen are increasingly being used for suicide, this study aims to advance this literature by:

- Identifying Australian trends in the gases used in suicide; specifically CO, helium, nitrogen, argon, butane, domestic gas/methane, hydrogen sulphide, liquid petroleum gas, nitrous oxide and unspecified aerosols;
- Determining whether there are demographic differences between individuals who suicide using helium and/or nitrogen gases, other non-CO gases, or CO;
- Investigating the extent that gas suicide mechanism material is being accessed using available qualitative narrative report data (i.e. coronial findings and police narratives).

Method

Study design and data sources

Unit-level mortality data were acquired from the NCIS for all registered suicide deaths in Australia where the underlying cause of death was determined as intentional self-harm. Data were obtained for January 2006 to December 2017 and comprised 31,002 deaths recorded in the NCIS as intentional self-harm (ICD-10 X60-X84) based on ICD-10 codes assigned by the Australian Bureau of Statistics (ABS). More recent data, particularly from 2018 onwards, contain open cases where coronial investigation is still underway and accordingly 2018 data were not included in this study.

Ascertainment of gas suicides

Suicides deaths by gas were identified using relevant NCIS primary object/mechanism codes (Supplementary File 1) and coronial cause of death determination free text (Supplementary File 2). Potential cases were those in which these codes or text included any reference to specific gases or gas toxicity. All available demographic information relating to the deceased, coded data detailing the circumstances of the death, and attached autopsy, coroner, police and toxicology documentation were reviewed further by at least one of the authors to confirm that each suicide was the result of asphyxiation by a specified gas.

Demographics characteristics

For each of the unit-level incident cases, data were collected on:

- Age: years
- Age group: 14–24, 25–64, 65–84, 85+ years (labelled as 'youth', 'working age', 'retiring' and 'elderly' respectively)
- Sex: male or female
- Marital status: never married, married/de-facto, separated, divorced, widowed, unlikely to be known
- Employment status: employed, unemployed/other, retired/pensioner, student/school age, unlikely to be known

Qualitative narrative coding

All non-carbon monoxide gas suicides (n=722) were isolated and narrative information from police and coroners was reviewed by at least one author. The qualitative circumstances prior to death were recorded as binary (yes/no) variables:

- Specified physical illness and/or disability
- Specified mental disorder
- Evidence of contact with a euthanasia network
- Evidence individual accessed instructional material for asphyxia by non-carbon monoxide gas (online and/or print)
- Evidence indicating gas ordered online.

Statistical analysis

Suicide deaths were grouped by use of helium and/or nitrogen gases (HeN), other non-CO gases (nonCO) and CO gas (CO). Data were compared on demographic variables. HeN and nonCO subgroups were compared on available narrative circumstances. Proportions were presented for categorical variables. Chi-square analyses were used to determine if there were differences between groups on categorical variables, reporting χ^2 and Cramer's V effect statistics. Where there were significant χ^2 values, pairwise examinations were performed to determine significant group differences, with odds ratios (ORs) and 95% confidence intervals (CIs) reported. For continuous variables, one-way analysis of variance (ANOVA) was used with means and standard deviation of the mean (SD) reported. Where significant, Tukey's post hoc comparison was performed to determine group mean differences.

Trends in gas-specific suicide over the study period were assessed for overall gas suicide – argon, butane, domestic gas/methane, helium, hydrogen sulphide, liquefied petroleum gas and nitrogen gas suicide – using negative binomial regression, with annual gas-specific suicide counts as the dependent variable and total population for each year as the offset. For all regression models, coefficients were transformed into incident rate ratios (IRR) and 95% CIs were estimated to aid interpretation. Analyses were performed using SAS Enterprise Guide 7.1[12] and R Studio 4.0.0.[13] Alpha was set at 0.01 for all analyses.

Results

There were 31,002 suicides in Australia over the 12-year period (2006–2017). Of the these, 3,103 (10%) used gases with ten sources of gases identified. For the total sample (n=3,103), the mean age at point of death was 47.6 years (SD 16.9, *R* 14-97) and 83.3% were male. Approximately three-quarters (77%) of the confirmed gas suicides were the result of CO gas (Table 1). Of the remaining 722 non-CO gas suicides, the largest number were the result of asphyxiation by helium (12%), followed by nitrogen (5%), liquefied petroleum gas (3%), hydrogen sulphide (1%), argon (0.6%), butane (0.5%), domestic gas/methane (0.4%), nitrous oxide (0.3%) and aerosols (0.2%).

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Trends in use of different gases

The overall number of suicides involving gas declined over the study period, from 309 in 2006 to 251 in 2017 (IRR=0.96, 95%CI=0.95-0.97), see Table 2. The decline in gassing is reflected in a reduction of CO suicides, which decreased by 47% over the study period (n=282 cases in 2006 to n=150 cases in 2017) (IRR=0.93, 95%CI=0.92-0.94), see Figure 1. The decline in CO suicides appears to have occurred simultaneously with an increase in the number of suicides by argon (IRR=1.60, 95%CI=1.30-2.11) and nitrogen (IRR=1.27, 95%CI=1.12-1.34).

Comparison of demographic characteristics across gas groups

Suicide deaths were compared based on the groups of HeN, nonCO and CO (Table 3). Significant differences between groups were reported for all demographic variables (Table 4). There was a significantly lower proportion of deaths among males in the HeN group compared to CO (OR=0.69, 95%CI: 0.55-0.88). There was a significant difference in age at death (F=10.14, $p<0.0001$). Tukey post hoc comparisons revealed that age was significantly higher for the HeN group (49.9 ± 20.3 years, $p=0.01$) compared to the CO group (47.5 ± 15.9 years) and nonCO group (43.6 ± 17.7), as well as being significantly lower for the nonCO group (43.6 ± 17.7, $p=0.01$) compared to the CO and HeN groups. More specifically, the HeN group had a higher proportion of 'youth' (OR 1.82, 95%CI: 1.33-2.51), 'retiring' (OR 1.50, 95%CI: 1.16-1.95), and 'elderly' (OR 3.26, 95%CI: 2.13-4.98) suicides compared to CO group. The nonCO group had a higher proportion of 'youth' (OR 2.66, 95%CI: 1.73-4.09) compared to the CO group. Being of 'working' age was more strongly associated with CO group than with HeN (OR 0.48, 95%CI: 0.39-0.59) and nonCO (OR 0.61, 95%CI: 0.44-0.85) groups.

Both the HeN (OR 0.58, 95%CI: 0.47-0.70) and nonCO (OR 0.56, 95%CI: 0.41-0.76) groups had a lower proportion of individuals with current employment compared to CO. The HeN group was associated with a higher proportion of retirees and/or pensioners compared to the CO group (OR 1.69, 95%CI: 1.37-2.09). Both the HeN (OR 3.18, 95%CI: 1.98-5.11) and nonCO (OR 4.20, 95%CI: 2.26-7.81) groups had a higher proportion among children and/or students than CO.

A high proportion of individuals who were never married was reported for HeN (OR 1.65, 95%CI: 1.33-2.04) and nonCO (OR 2.07, 95%CI: 1.51-2.84) groups compared to the CO group. The HeN group had a lower proportion of both separated (OR 0.67, 95%CI: 0.51-0.89) and married individuals (OR 0.71, 95%CI: 0.57-0.88) compared to the CO group.

Comparison of qualitative narrative coding for HeN and nonCO gas groups

To examine and establish the profile of deaths involving non-CO gases available, narrative documents (i.e. coronial findings, autopsy

Figure 1: Time trends in suicides by gas in Australia, 2006–2017.

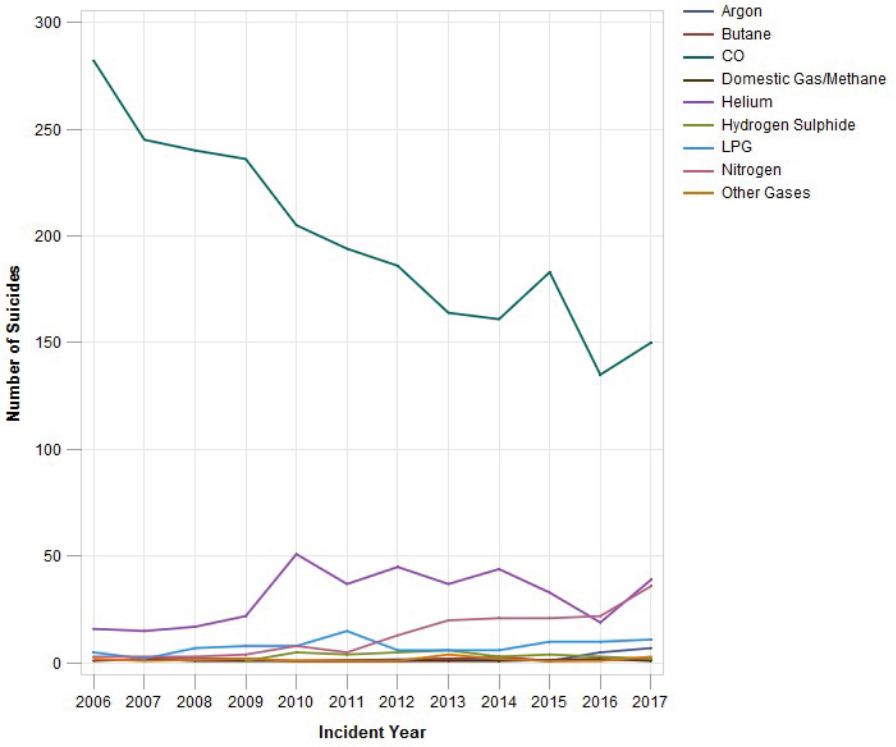

Table 1: Gas suicides in Australia, by gas type, 2006-2017.

Type of gas	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Carbon monoxide (CO)	282 (91%)	245 (92%)	240 (90%)	236 (86%)	205 (73%)	194 (75%)	186 (72%)	164 (68%)	161 (66%)	183 (72%)	135 (69%)	150 (60%)	2,381 (77%)
Non-CO gas	27	22	28	40	76	63	72	78	82	71	62	101	722
Argon	0	0	0	0	np	0	0	np	np	np	5 (3%)	7 (3%)	18 (0.6%)
Butane	np	np	0	np	np	0	np	np	np	np	0	np	15 (0.5%)
Domestic gas/methane	0	np	np	np	np	np	np	np	np	0	np	np	12 (0.4%)
Helium	16 (5%)	15 (6%)	17 (6%)	22 (8%)	51 (18%)	37 (14%)	45 (17%)	37 (15%)	44 (18%)	33 (13%)	19 (10%)	39 (16%)	375 (12%)
Hydrogen sulphide	0	0	0	np	5 (2%)	np	5 (2%)	6 (2%)	np	np	np	np	33 (1%)
Liquefied petroleum gas	5 (2%)	np	7 (3%)	8 (3%)	8 (3%)	15 (6%)	6 (2%)	6 (2%)	6 (2%)	10 (4%)	10 (5%)	11 (4%)	94 (3%)
Nitrogen	np	0	np	np	8 (3%)	5 (2%)	13 (5%)	20 (8%)	21 (9%)	21 (8%)	22 (11%)	36 (14%)	156 (5%)
Other gases	np	np	0	np	np	np	np	np	np	np	np	np	19 (0.6%)
Total gas suicides	309	267	268	276	281	257	258	242	243	254	197	251	3103
Total suicides	2,289	2,324	2,385	2,385	2,391	2,382	2,644	2,632	2,791	2,960	2,741	3,078	31,002
Population	20,450,966	20,827,622	21,249,199	21,691,653	22,031,750	22,340,024	22,733,465	23,128,129	23,475,686	23,815,995	24,190,907	24,601,860	

Note:

np counts not provided where they are < 5 for confidentiality reasons as required by the NCIS. Aerosol, nitrous oxide, and unnamed gases were grouped as "other gases" due to low counts.

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Table 2: Incidence rate ratios of gas suicides in Australia, by gas type, 2006–2017.

Type of gas	IRR	Lower CI	Upper CI
Argon	1.60**	1.30	2.11
Butane	1.01	0.87	1.17
CO	0.93**	0.92	0.94
Domestic gas/methane	1.00	0.84	1.18
Helium	1.05	0.98	1.07
Hydrogen sulphide	1.13	0.99	1.31
Liquefied petroleum gas	1.04	0.98	1.11
Nitrogen	1.26**	1.20	1.34
Total gas suicides	0.96**	0.95	0.97

Notes:

IRR suicide rates expressed as per 100,000 person years. Lower CI 95% Interval as the lower bound; Upper CI 95% CI Interval as the upper bound. IRRs were not calculated for aerosol, nitrous oxide and unnamed gases due to low counts.

**p < 0.01 **p < 0.001 ***p < 0.0001*

and/or police reports) were reviewed by at least one researcher (AB all; SZ subset) for qualitative evidence of a physical illness and/or disability, specified mental disorder, contact with a euthanasia network, accessing instructional documentation for asphyxia by gas and ordering of gas online (inter-rater agreement kappa=0.80). Significant associations were found between the HeN group and evidence of physical illness and/or disability ($\chi^2(1)=16.12$, $p<0.0001$), contact with a euthanasia society or support ($\chi^2(1)=17.98$, $p<0.0001$), accessing instructional documentation ($\chi^2(1)=26.14$, $p<0.0001$) and purchase of gas online ($\chi^2(1)=11.70$, $p=0.0006$), see Table 5. No differences were found related to specified mental disorders or previous suicide attempts.

Table 3: Demographic characteristics of gas groups.

	HeN (n = 531)	non-CO (n=191)	CO (n=2,381)	Statistical Significance	Significant differences between groups
Demographics					
Sex (male) n (%)	419 (78.9)	158 (82.7)	2,001 (84.4)	χ2=9.41, p=0.0091, Cramer's v=0.06	HeN < CO
Age (years) M ± SD	49.9 (20.3)	43.6 (17.7)	47.5 (15.9)	F=10.14, p= p<0.0001	HeN > CO, nonCO; nonCO < CO, HeN
Age groups n (%)					
14–24 (Youth)	58 (10.9)	29 (15.2)	150 (6.3)	χ2=29.58, p=<0.0001, Cramer's v=0.10	HeN, nonCO > CO
25–64 (Working)	347 (65.4)	135 (70.7)	1,898 (79.7)	χ2=54.27, p<0.0001, Cramer's v=0.13	HeN, nonCO < CO
65–84 (Retiring)	88 (16.6)	24 (12.6)	278 (11.7)	χ2=9.47, p=0.0088, Cramer's v=0.06	HeN > CO
85+ (Elderly)	38 (7.2)	*np*	55 (2.3)	χ2=35.59, p<0.0001, Cramer's v=0.11	HeN > CO
Employment status n (%)					
Employed	190 (35.8)	67 (35.1)	1,170 (49.1)	χ2=40.94, p<0.0001, Cramer's v=0.11	HeN, nonCO < CO
Unemployed/Other	86 (16.2)	48 (25.1)	442 (18.6)	χ2=7.42, p=0.0245, Cramer's v=0.05	-
Retired/Pensioner	153 (28.8)	36 (18.9)	460 (19.3)	χ2=24.19, p<0.0001, Cramer's v=0.09	HeN > CO
Child/Student	30 (5.7)	14 (7.3)	44 (1.9)	χ2=37.69, p<0.0001, Cramer's v=0.11	HeN, nonCO > CO
Unlikely to be known	72 (13.6)	26 (13.6)	265 (11.1)	χ2=3.20, p=0.2016, Cramer's v=0.03	-
Marital status n (%)					
Never married	152 (28.6)	64 (33.5)	466 (19.6)	χ2=36.53, p<0.0001, Cramer's v= 0.11	HeN, nonCO > CO
Widowed	34 (6.4)	7 (3.7)	104 (4.4)	χ2=4.50, p=0.1053, Cramer's v=0.04	-
Divorced	49 (9.2)	10 (5.2)	220 (9.2)	χ2=3.51, p=0.1730, Cramer's v=0.03	-
Separated	64 (12.1)	28 (14.7)	404 (17.0)	χ2=7.90, p=0.0192, Cramer's v=0.05	HeN < CO
Married (incl. de facto)	145 (27.3)	55 (28.8)	823 (34.6)	χ2=12.36, p=0.0021, Cramer's v=0.06	HeN < CO
Unlikely to be known	87 (16.4)	27 (14.1)	364 (15.3)	χ2=0.65, p=0.7219, Cramer's v=0.01	-

Notes:

np counts not provided where they are < 5 for confidentiality reasons as required by the NCIS. CO: carbon monoxide, HeN: helium and nitrogen gas, nonCO: argon, butane, domestic gas/methane, hydrogen sulphide, liquid petroleum gas, nitrous oxide and unspecified aerosols

Discussion

The use of gases as a method of suicide in Australia declined over the study period, from 309 cases in 2006 to 251 cases in 2017. This finding is consistent with other studies that have documented an overall reduction in the use of CO as a method of suicide both in Australia[2] and internationally.[1,3] Observed declines in CO gas suicides have been linked to changes in emission control regulations that require new motor vehicles to be fitted with catalytic converters, reducing the overall lethality of motor vehicle gas.[2] Contemporaneously, suicides by non-CO gases have become increasingly common.[1] It is possible that the increase in non-CO gas suicides may be associated with the availability of material detailing the gas suicide method.[9] Indeed, we found evidence that gas suicide mechanism material was accessed in one-fifth of suicides by helium or nitrogen gas. High lethality suicide methods, such as non-CO gas suicide, can impact overall suicide incidence by limiting opportunity for intervention by a third party.[1]

Among gas suicides in Australia, the number of helium suicides increased from 16 cases in 2006 to 39 cases in 2017. Similarly, there was an increase in the number of nitrogen suicide deaths in the latter part of the study period, rising to 36 cases in 2017. This is consistent with earlier studies that noted increasing numbers of helium and nitrogen suicide deaths.[3,7] For example, in South Australia, a study of helium and nitrogen suicide deaths between 2003 and 2017 reported a steady increase in deaths from both helium and nitrogen, with nitrogen surpassing helium by the end of the study period.[7] In the US, a study of gas suicide data between 2005 and 2015 reported a significant increase in the number of suicides by helium, with a small increase in the nitrogen suicides between 2010 and 2012.[3] While argon suicide deaths were uncommon over the study period, there was an increase in the number of argon suicides between 2015 and 2017.

There are several possible explanations for the rising trend in nitrogen suicides. Firstly, the increase coincides with a recommendation from a New Zealand Coroner in 2011 to dilute helium sold as a party supplement with a mixture of oxygen to limit the lethality of the gas.[14] Secondly, due to global helium

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supply issues, the largest manufacture of disposable helium containers, Worthingtons (USA), began to supplement their helium products with 0–15% oxygen in 2015.[15] In the response to the dilution of disposable helium containers in the Australian domestic market, the author of Final Exit,[8] Derek Humphry, recommended the discarding of previously acquired helium containers in favour of nitrogen in 2015.[16]

Our data show that those who died by helium or nitrogen gas, compared to other types of gases, had characteristic features of elderly suicide, in that they were more likely to have a physical illness and/or disability.[17] Those who died by helium or nitrogen were also more likely to have had contact with a euthanasia society, accessed instructional documentation and purchased the gas online. These findings suggest that the relatively easy access to helium and/or nitrogen gases may be a key enabler for suicide attempts among those who perceive their quality of life to be low – be that for health, social or interpersonal reasons. This access issue may also be important to young people, in that 10.9% of helium and nitrogen suicides were by people aged under 25 years. It is likely that younger persons dying by suicide using such gases have an awareness of the methodology given the visibility of material detailing suicide methods online.[18] Future studies are needed to better understand the prevalence, incidence, predictors and characteristics of gas suicide in Australia to illuminate entry points for intervention in high-risk groups. These include promoting help resources and crisis line numbers to young people searching for suicide methods online, and systematic efforts to train community members – including promoting training in the detection and responding to signs of suicidal crisis in schools, workplaces, and aged care facilities to reach the family, friend, and carer networks of at-risk persons. Simultaneous efforts to reduce the ease of access to gases are also needed, as suicide attempts can be impulsive. There is evidence to suggest that simple measures to restrict access to means at the time of crisis may allow time for suicidal impulses to pass or for intervention to occur.[19]

Study limitations

This study used suicide mortality data available within the NCIS database, which includes intent type based on the findings of the investigating coroner. Coroners are bound to a standard of proof when determining intent, known as the Briginshaw Test. In some instances, a coroner is unable to make a finding of intentional self-harm based on this standard, which may result in an open finding as to intent (coded as undetermined intent on the NCIS). The identification of gas asphyxia suicides was subject to a mixed novel methodology that relies on NCIS object and mechanism codes and coronial free-text strings being available and accurately coded. Furthermore, identification also relies on specific codes being accounted for in the NCIS data dictionary. There is no code for nitrous oxide in the current NCIS data dictionary and it can only be identified using a free-text search, rather than existing mechanism and object codes. The NCIS also does not currently contain any structured data regarding the circumstances of the individual prior to suicide.

Table 4: ORs and CIs for significant independent correlates of suicide by gas group (CO treated as referent).

	HeN vs CO			nonCO vs CO		
	OR	Lower CI	Upper CI	OR	Lower CI	Upper CI
Sex	0.70*	0.55	0.88			
14–24 (Youth)	1.82**	1.32	2.50	2.66***	1.73	4.07
25–64 (Working)	0.48***	0.39	0.59	0.61*	0.44	0.85
65–84 (Retiring)	1.51*	1.16	1.96			
85+ (Elderly)	3.31***	2.16	5.07			
Employed	0.58***	0.47	0.70	0.56**	0.41	0.76
Unemployed/Other				1.47	1.04	2.07
Retired/Pensioner	1.70***	1.37	2.10			
Child/Student	3.17***	1.97	5.09	4.19***	2.25	7.79
Never married	1.64***	1.33	2.03	2.06***	1.50	2.83
Widowed	1.49	1.00	2.22			
Separated	0.67*	0.51	0.89			
Married (incl. de facto)	0.71*	0.58	0.88			

Notes:

OR as the odds ratio. Lower CI 95% Interval as the lower bound; Upper CI 95% CI Interval as the upper bound. CO: carbon monoxide, HeN: helium and nitrogen gas, nonCO: argon, butane, domestic gas/methane, hydrogen sulphide, liquid petroleum gas, nitrous oxide and unspecified aerosols

**p < 0.01 **p < 0.001 ***p < 0.0001*

Table 5: Comparison of HeN and nonCO by manually coded risk factors.

		HeN (n=531)	nonCO (n=191)	Significance
		n (%)	n (%)	
Physical illness and/or disability	Yes	163 (30.7)	30 (15.7)	χ^2 (1) = 16.12***
	No	368 (69.3)	161 (84.3)	Cramer's v = -0.15
Specified mental disorder	Yes	262 (49.3)	105 (55.0)	χ^2 (1) = 1.78
	No	269 (50.7)	86 (45.0)	Cramer's v = 0.05
Contact with a euthanasia society or support group	Yes	58 (10.9)	np	χv (1) = 17.98***
	No	473 (89.1)	189 (99.0)	Cramer's v = -0.16
Accessed instructional documentation	Yes	110 (20.7)	9 (4.7)	χ^2 (1) = 26.14***
	No	421 (79.3)	182 (95.3)	Cramer's v = -0.19
Purchased gas online	Yes	37 (7.0)	np	χ^2 (1) = 11.70**
	No	494 (93.0)	190 (99.5)	Cramer's v = -0.13
Previous attempt(s)	Yes	110 (20.7)	45 (23.6)	χ^2 (1) = 0.67
	No	421 (79.3)	146 (76.4)	Cramer's v = 0.03

Notes:

np counts not provided where they are <5 for confidentiality reasons as required by the NCIS

**p <0.01 **p <0.001 ***p <0.0001*

Researchers manually coded narrative information, which was subject to the availability of this information within attached case reports. While it does provide some insight into the circumstances of gas suicides, it is subject to under-reporting. Furthermore, carbon monoxide suicides were not manually coded for narrative information due to the high number of records and associated resourcing costs.

Conclusion

The increasing incidence of nitrogen suicides in Australia, and the parallel decrease in CO suicides, strongly warrants continued surveillance of trends in specific types of gas suicides over time to ensure suicide prevention efforts are responding to emerging trends as they appear. The discrete

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and easy access to gases – such as through online purchasing – means that this particular method may appeal to high-risk groups who have a strong desire to die, and this will create challenges in intervening in timely and effective ways to prevent suicide. However, the clear reductions in CO suicides as a result of the detoxification of motor vehicle exhaust gas shows that effective intervention is possible. Increased efforts to improve national surveillance of gas use in suicide attempts and deaths will be important for advancing our understanding of who is at risk of choosing this means of suicide so that optimal opportunities for intervention can be identified.

What is already known on this subject

- Incidents of asphyxia suicide using helium have been increasing across Australia, the UK, the US and Hong Kong.
- Incidents of asphyxia suicide using nitrogen have been increasing in South Australia, Australia.
- Intentional self-harm databases have been used previously to identify non-CO gas suicides with high sensitivity and positive predictive value.
- Information detailing suicide methodologies, such as asphyxia using helium gas, can be accessed online and have been linked to suicide incidents in Hong Kong and the UK.

What this study adds

- Specific gases involved in suicides can be identified using routinely coded mechanism and object codes contained within the National Coronial Information System.
- Incidences of suicide using a non-CO gas, most notably nitrogen gas, have increased across Australia.
- There appears to be increasing numbers of people who are taking their own lives in the context of deteriorating physical conditions using the gas asphyxia methodology. These individuals are more likely to have had contact with euthanasia groups, accessed instructional material detailing gas asphyxia and purchased non-CO gas online.
- Young people also appear to be taking their own lives using gas asphyxia methodology.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary File 1: NCIS mechanism and object.

Supplementary File 2: Coronial Cause of Death free text string search criteria.

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