Alcohol-related suicide across Australia: a geospatial analysis

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Abstract

Background: The acute effects of alcohol consumption are a major risk factor for suicide. Positive blood alcohol concentrations are present in almost one-third of all suicides at time of death. These suicides are defined as alcohol-related suicides. This cross-sectional study examines the geospatial distribution/clustering of high proportions of alcohol-related suicides and reports on socioeconomic and demographic risk factors.

Methods: National Coronial Information System (NCIS) data were used to calculate proportions of suicides with alcohol present at the time of death for each level 3 statistical areas (SA3) in Australia. A density analysis and hotspot cluster analysis were used to visualise and establish statistically significant clustering of areas with higher (hotspots) and lower (coldspots) proportions. Subsequently, socioeconomic and demographic risk factors for alcohol use and suicide were reported on for hot and cold spots.

Results: Significant clustering of areas with higher proportions of alcohol-related suicide occurred in northern Western Australia, the Northern Territory and Queensland, as well as inland New South Wales and inland Queensland. Clustering of SA3s with significantly lower proportions occurred in major city and inner regional Sydney and Melbourne.

Conclusion and implications for public health: Results from this study identify areas in which prevention strategies should target alcohol use and can be used to inform prevention strategy design. Additionally, hotspots and coldspots identified in this study can be used for further analysis to better understand contextual risk factors for alcohol-related suicide.

Key words: alcohol, suicide, alcohol-related suicide, acute alcohol use

In Australia, suicide is the leading cause of death in the 15–44 years age group and the second highest in the 45–65 age group.[1] Alcohol consumption is one of the most significant proximal risk factors for suicidal behaviour.[2] When alcohol is consumed in the minutes or hours before the attempt, henceforth described as 'acute alcohol consumption', suicide attempts are more likely to become suicides.[3] An international review reported anywhere between 10% and 69% of suicide cases contain a positive blood alcohol concentration (BAC) at time of death.[4]

Population-level interventions may mitigate damage induced by acute alcohol consumption and improve outcomes for individuals who have yet to be identified as being at risk of suicide (i.e. those without previous psychiatric history). Alcohol policies have been shown to be among the most effective population-level interventions for influencing drinking levels, drinking patterns and alcohol-related negative outcomes.[5] These forms of interventions tailored to specific communities have been suggested as an effective way to reduce the rate of suicide.[6] Targeting and applying interventions tailored to alcohol and suicide in areas afflicted with high rates of alcohol-related suicide may aid in reducing suicide rates as a whole.

Geospatial analysis techniques such as density and hotspot cluster analysis are used in epidemiological studies to visualise the distribution of events and identify areas that experience high occurrences of events. These exploratory techniques indicate areas of interest that may be further investigated to define the specific context in which these events occur. Geospatial analysis can be used to inform targeted prevention, diagnosis and treatment to improve health outcomes and reduce inequalities between geographical areas. In the Australian literature pertaining to suicide, these techniques have been used to outline high-risk areas. Geospatial analysis techniques have previously identified that northern Queensland, inland Queensland, the east coast of Queensland and Tasmania, New South Wales and Western Australia, as well as the southern areas of Northern Territory experience higher age and sex standardised suicide rates.[7-9]

The primary aim of this study is to explore the distribution and identify areas with high proportions of alcohol-related suicides in Australia. We hypothesise that areas with higher proportions of alcohol-related suicide will be areas previously shown to have higher rates of suicides. Currently, there is little

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research investigating the spatial variation in the number of alcohol-related suicides in Australia, however, research has previously demonstrated variations in consumption of alcohol[10] and suicide,[7,8] and that alcohol is a risk factor for suicide.[11] The study uses geospatial data analysis and visualisation techniques on suicide data (between 2010 and 2015) obtained from the National Coronial Information System (NCIS). Density analysis is used to visualise the proportions of alcohol-related suicide while hotspot analysis is used to demonstrate clustering of areas with high and low proportions of alcohol-related suicide, and to report on the characteristics of these areas.

Methods

This study was approved by the Justice Department Human Research Ethics Committee (Reference: CF/16/18940) and the Western Australian Coroners Court (Reference: EC07-2016).

Case inclusion and coronial information

Methods and rationale for case inclusion and toxicological analysis have been described in detail elsewhere.[12] In brief, data for intentional self-harm cases between 2010 and 2015 in Australia were obtained from the NCIS, which contains coronial information on every death reported to a coroner in Australia. For each case we extracted information on age, sex and residential address at the time of death as well as BAC detected at autopsy. Based on the toxicology information, further inclusion criteria were applied to ensure post-mortem BAC were available and were valid for included cases. Cases were included in this analysis if all information pertinent to the geospatial analysis was available for each case. There was some systematic missingness noted, in that no toxicology reports (and hence no BAC) were available for suicides in SA in 2010 and 2011.

Geospatial information

Geocodes at statistical area level 3 (SA3) pertaining to residential address at time of death were used. There are 333 SA3 that break Australia down into different regions and separates areas that generally experience distinct identities as well as socioeconomic and demographic characteristics. This study required SA3 shapefiles, which are digital files that outline statistical boundaries for each SA3. SA3 shapefiles from 2011 were obtained from the Australian Bureau of Statistics.[13] Additional SA3 population-level information such as remoteness value and Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) were obtained from the Australian Bureau of Statistics (ABS)[14-17] within the 2010–2015 study period. IRSAD is a rank of socioeconomic disadvantage including variables such as income, unemployment and education.[16] Remoteness rating is a measure of accessibility to a range of services, goods and opportunities for social interaction and is separated into major city, inner regional area, outer regional area, remote area and very remote.[14,15] Data for population percentage service use of general and mental healthcare as measured through administrative claims in 2013/14 were obtained from the Australian Institute of Health and Welfare[18] for available SA3 areas. Data were provided as the percentage of people in that SA3 who accessed a mental health or general health service throughout the timeframe. Estimates were then listed in rank order and spilt into deciles for display. General healthcare includes government-subsidised patient/doctor encounters such as general practitioner (GP) practice incentive program services, after-hours GP attendances, enhanced primary care, and 'other' GP services. This category does not include services provided by practice nurses and Aboriginal and Torres Strait Islander health practitioners on a GP's behalf. Mental healthcare includes the assessment, management and treatment of individuals with mental disorders by psychologists and other allied mental health workers. Mental healthcare estimates also included claims for psychological telehealth services for rural and remote areas from 1 November 2017.

Software packages RStudio (RStudio, Inc/1.2.5001/2019) and ArcGIS (ESRI/10.7/2019) were used to analyse and visualise data.

Determination of alcohol-related suicides

Cases were categorised as either alcohol (Alc+) or non-alcohol (Alc-) related suicides based on BAC determined at autopsy, with BAC ≥0.05g/100mL categorised as Alc+. This threshold has been applied in various other alcohol-related suicide research.[12,19]

Cases in which BAC ≥0.05g/100ml were considered to be Alc+ suicides for various reasons:

- Adverse psychological effects of acute alcohol consumption become more severe at BAC ≥0.05 g/100ml.[11]
- A BAC ≥0.05 g/100ml has been associated with impaired cognition and therefore considered to be the legal limit for operating motor vehicles in Australia.[6]
- Lower levels of post-mortem BAC can be caused by endogenous production of alcohol during decomposition (BAC ≤ 0.03g/100ml).[7]

Data analysis

Age and sex data for each SA3 were extracted from the 2011 ABS Census.[20] Subsequently, in R Studio, age and sex standardised mortality rates (SMR) for Alc+ and total suicides (the sum of Alc+ and Alc- SMR) per SA3 were calculated using the following formula:

$$SMR = \frac{ObservedRate}{ExpectedRate} \cdot 100000 = \frac{\sum X_i}{\sum R \cdot K_i} \cdot 100000$$

X_i = Number of observed suicides in SA3 across all sex and age groups for SA3 i

R = Australian suicides rates for each age and sex group

K_i = Population of SA3 stratified by age and sex for SA3 i

For each SA3, Alc+ SMR was divided by total SMR in order to calculate the percentage of Alc+ suicide, henceforth referred to as standardised proportions of Alc+ suicides. These SA3 standardised proportions of Alc+ suicides were subsequently represented in a density analysis using ArcGIS.

Following the density analysis, a hotspot cluster analysis was conducted using ArcGIS to identify clustering of SA3s with high and low proportion of Alc+ suicide cases. This analysis functions by measuring the spatial autocorrelation within a variable and is indicative of influence from systematic protective and risk factors.[21] Spatial autocorrelation is a measure of a variable's correlation with itself through space and is a measure of randomness in the spatial distribution of data. Spatial autocorrelation is calculated by summing each SA3 with proximal SA3s (the local sum) and proportionally comparing it to the sum of all SA3 features using the Getis-Ord Gi* statistic (the expected sum).[22] In this study, a 100 km boundary was used to define proximity, as has been used in other previous studies.[7,8] When the sum of proximal SA3s was very different from the sum of all SA3s in Australia, and when this difference was too large to be

the result of random chance, a z-score that was statistically significant resulted ($p<0.1$, $p<0.05$, $p<0.01$).

After having located hotspots, socioeconomic and demographic Alc+ suicide risk factor for alcohol use and suicide were reported and trends were investigated. Reporting was conducted to identify differences and similarities in contextual factors between clusters and other areas. This is a procedure that has been conducted in various other studies pertaining to suicide and alcohol use.[7-9] Variables reported on were those which have previously been suggested to be risk factors for suicide and alcohol use. These included SA3 remoteness value, Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) rankings, mental health treatment access and general health treatment access.

Results

The analysis included 10,164 suicide cases over the timeframe that satisfied the inclusion criteria for the study; 26.9% of these were Alc+. Figure 1 shows the density analysis which depicts standardised proportions of Alc+ suicides. Proportions were split into five even categories of 20% intervals with higher percentages being represented with higher saturations of colour. To facilitate comprehension of the visualisations, urban areas with denser distributions of SA3s were enlarged. This density analysis (Figure 1) suggests that areas in northern Queensland and Western Australia, inland Queensland, New South Wales and Western Australia, south-western Victoria and much of the Northern Territory are primarily affected by high proportions (between 60% to 100%) of Alc+ suicide.

Figure 2 illustrates SA3 areas with high spatial autocorrelation to proximal areas (i.e. any SA3 included in the 100 km around their border) as well as higher (represented by red tones) or lower (represented by blue tones) than average standardised proportions of Alc+ suicides. Therefore, hotspots can be considered as statistically significant as opposed to random spatial variation with 90, 95 and 99% represented with increasing saturation for increasing confidence. Figure 2 represents randomness and therefore non-significant areas (represented by cream tones) may have higher than average proportions of alcohol-related suicide but will not be indicated by the analysis.

Hot and cold spots identified in Figure 2 were reported on for remoteness value, IRSAD rankings, mental healthcare use and general medical use in Table 1. There was a general trend of hotspots appearing in more remote areas than cold spots. There was a general trend of hotspot areas ranking average or below average for IRSAD measurements and low deciles in terms of general and mental health care access.

Discussion

The results from this study indicate that standardised proportions of Alc+ suicide vary significantly across Australian SA3s. Interestingly, the pattern of distribution of SA3s with higher proportions of Alc+ suicides (Figure 1) was similar to those found to have elevated total suicide SMR in previous studies.[8] This may suggest that socio-demographic and environmental

Table 1: Indicators of remoteness, socioeconomic status and healthcare use for highest and lowest risk areas for alcohol-related suicides.

Significant areas	Remoteness Index**	IRSAD (Quintile)	Mental healthcare use*** (Decile)	General medical use (Decile)
Hotspots 99%				
Kimberley	5	1	1	1
Katherine	5	1	1	1
Litchfield	3	3	1	3
Darwin City	3	5	2	2
Darwin Suburbs	3	4	1	1
Palmerston	3	5	1	2
Murray River – Swan Hill*	3	1	2	9
Barkly	5	1	1	1
Hotspots 95%				
Outback – North	5	3	1	1
Port Douglas – Daintree	4	2	2	4
Pilbara	5	4	1	1
Lower North	2	1	2	5
Far North	1	1	1	1
Hotspots 90%				
Townsville	3	2	6	4
Central Highlands (QLD)	4	1	1	3
Bourke – Cobar – Coonamble	4	1	1	5
Charters Towers – Ayr – Ingham	5	1	2	3
Midwest	2	2	1	2
Whisunday	2	2	2	2
Mackay	3	6	2	4
Coldspots 99%				
Greater Melbourne*	1	5	NA	NA
Inner Regional Melbourne*	2	4	NA	NA
Greater Sydney*	1	5	NA	NA
Inner Regional Sydney*	2	5	NA	NA
Coldspots 95%				
Inner Regional Melbourne*	2	4	NA	NA
Inner Regional Sydney*	2	5	NA	NA
Coldspots 90%				
Inner Regional Melbourne*	2	4	NA	NA
Inner Regional Sydney*	2	5	NA	NA
Campaspe	2	1	3	10
Lake Macquarie	1	2	7	8
Lake Macquarie - East	1	4	7	9
Average	NA	3	5	

Notes:

** Bunched areas around Melbourne and Sydney were described inner regional and greater Sydney and Melbourne*

*** Major city = 1, Inner regional area = 2, Outer regional area = 3, Remote = 4, Very remote = 5.*

****Deciles presented are calculated based on rank of percent of persons in that SA3 who accessed a service in 2013/2014 compared to all other SA3 listings available.*

NA=Not available

Figure 1: Density analysis of standardised proportion of Alc+ suicide per SA3.

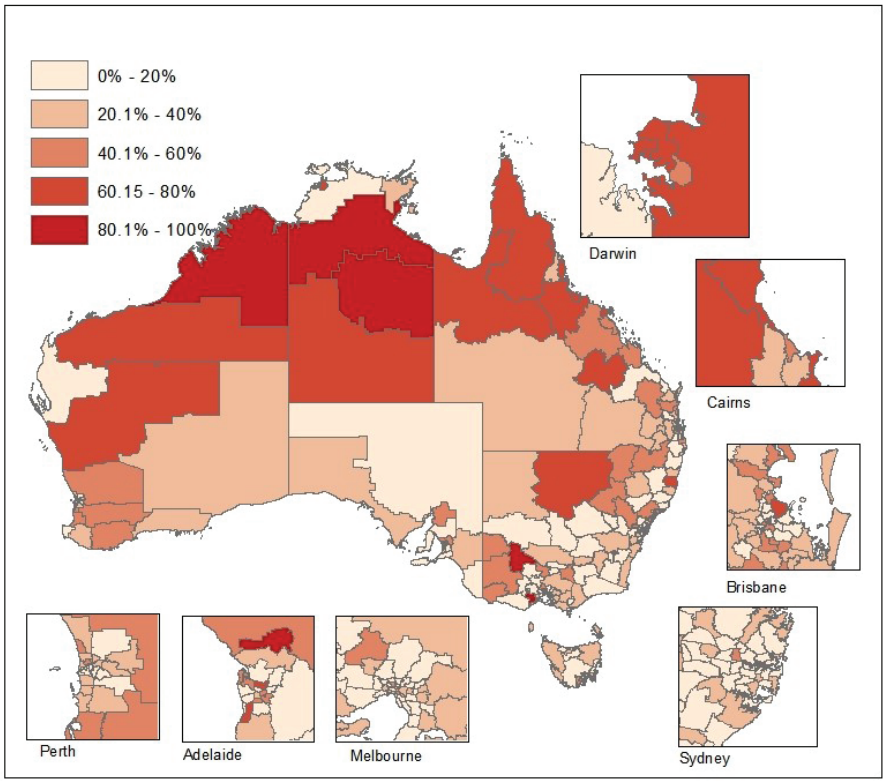
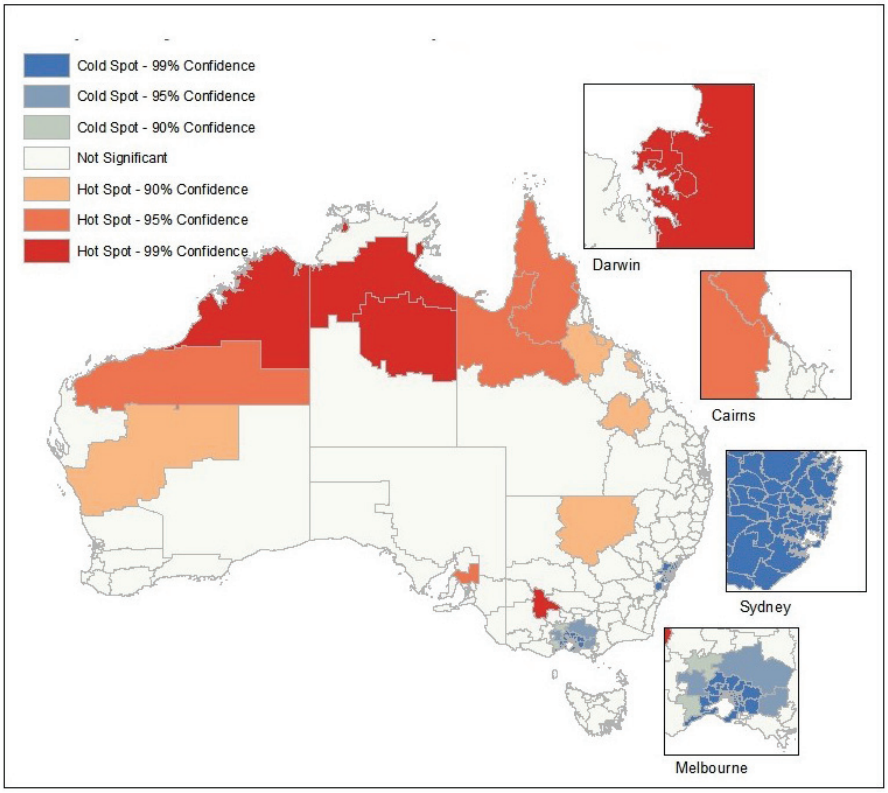


Figure 2: Hotspot cluster analysis of standardised proportions of Alc+ suicide per SA3 (radius limit of 100 km).



covariates influence both total suicide rates and alcohol use. Additionally, similarities in patterns of Alc+ suicide and total suicide could be due to acute alcohol use acting as a risk factor for inflated total suicide numbers. However, a density analysis provides only a representation of data without accounting for random error. This subsequently limits the validity of inferences that can be drawn, and as such a hotspot analysis was conducted to further investigate the distribution of Alc+ suicide proportions. Geographic areas with clustering of higher values (hotspots) included parts of northern Western Australia, Northern Territory and Queensland, as well as parts of inland New South Wales and Queensland. Clustering of significantly lower proportions (coldspots) occurred in major city and inner regional Sydney and Melbourne. This clustering of areas is indicative of influence from systematic protective and risk factors.[21]

All but two hotspot areas identified by our analysis were outer regional to very remote areas. Conversely, major city and inner regional areas around Sydney and Melbourne are shown to be coldspots, suggesting that living in urban areas may be a protective factor. Residing in rural and remote areas has previously been shown to be a risk factor for suicide in Australia.[23,24] This may be due to remote areas having reduced access to mental health services,[25,26] increased levels of social isolation and loneliness[27] and fewer targeted prevention strategies[28] in comparison to urban areas. Indeed, these areas were identified to access low amounts of general and mental healthcare. Additionally, rural and remote areas have higher rates of risky-drinking and total alcohol use,[29] as well as lower levels of pharmacotherapy for alcohol dependence.[30] These rural and remote areas additionally experience lower rankings of IRSAD. These findings are supported by the results in this study. Furthermore, socioeconomic disadvantages are risk factors for both suicidal behaviour[31] and alcohol use.[32]

Previous studies have indicated high suicide rates for males in the agricultural industry.[27] Agrarian cultural values such as self-reliance and independence[33] can become a barrier to seeking treatment and discussing mental health.[34] This coupled with the lack of proximity/availability of mental health services, social isolation and the stressors associated with farming and rural areas limits the number of individuals

receiving mental health care. Additionally, farmers have been shown to be more likely to drink excessively compared to those living in urban communities.[35] This may be an explanation for the higher proportions of alcohol suicide rates for hotspot areas with a large agriculture industry (areas such as Murray River – Swan Hill, Lower North, Burnett, Central Queensland Highlands and Wheat Belt – South). Some of the hotspots identified in our study are areas with a high proportion of Aboriginal and Torres Strait Islander people. Previous research has indicated that Aboriginal and Torres Strait Islanders experience twice the rate of suicide in comparison to non-Indigenous Australians.[36,37] This may be due to the significant health gap observed in Aboriginal and Torres Strait Islander people, which is further pronounced for remote areas.[38] Non-Indigenous Australians who died from suicide were shown to be twice as likely to receive mental health care compared to Aboriginal and Torres Strait Islander peoples (43.3% and 23.8% respectively).[39] Moreover, Aboriginal and Torres Strait Islander people experience a higher disease burden associated with alcohol.[40] Another population potentially highlighted in this analysis is ex-Australian Defence Force (ADF) members and their families. It has been shown that ex-ADF members are 3.27 times more at risk of experiencing suicide than those with other occupations.[41]

There is extensive ongoing work taking place in Primary Health Networks (PHN) around Australia to prevent suicide and mitigate alcohol-related harms; some are indeed areas that have been highlighted as hotspots in our current analysis. In 2017, the Fifth National Mental Health and Suicide Prevention Plan endorsed the use of systems-based approaches and led to national trials.[42] PHNs continue to be well-placed to deliver targeted systems-based approaches to health problems tailored toward the local communities. For example, as of 2021, the Australian Government is supporting the implementation of suicide prevention trials led by PHNs across 12 sites in Australia, with each trial site implementing prevention strategies specifically tailored towards the needs of their community. Some PHNs involved are hotspots identified in the current study, such as the Northern Territory PHN, Kimberley PHN and North Queensland PHN. Each trial site has priority target populations, Aboriginal and Torres Strait Islander communities in the Northern Territory and Kimberley and ex-Australian Defence Force members and families in North Queensland. Likewise, alcohol and drug strategies tailored towards specific communities have shown success. For example, community-driven initiatives in Aboriginal and Torres Strait Islander communities in Arnhem Land have shown reductions in substance use, improved resilience and connectedness.[43] Additionally, a primary care brief intervention[44] has been shown to reduce risky drinking in veterans. The current study would suggest that involving alcohol and drug treatment as a component of systems-based suicide prevention may be important, especially for PHNs in identified hotspots.

Limitations and future direction

Although the current study provides useful tools in suggesting prevention strategies for Alc+ suicides, certain methodological limitations should also be addressed and considered in the development of future research. Firstly, certain aspects of the available data may limit the validity of the study results. The NCIS data and socioeconomic and demographic variables were obtained from 2010 to 2015. These data and the study results cannot reflect any more recent interventions or changes to rates of Alc+ suicide in Australia. Given the recent implementation of the Fifth National Mental Health and Suicide Prevention Plan (between 2017 and 2022), future research using more recent data would provide useful ecological analyse and efficacy of systems-based approaches to suicide reduction.

The sensitivity of the analysis in identifying particular at-risk areas that are close in proximity to areas with low risk may also be limited. The NCIS data provided residence at the time of death for SA3. However, previous research indicates that high-risk impoverished areas can be buffered by areas of moderate poverty in Australia suggesting that this analysis may not be sensitive to certain at-risk areas.[45] Therefore, within SA3s there may be significant variation in community Alc+ suicide rates that would only be apparent with finer geospatial detail. Additionally, the current clustering strategy established spatial autocorrelation by comparing the variation between 100 km areas surrounding an SA3 with the spatial variation of the rest of Australian SA3s. As a result, some areas with higher rates of Alc+ suicide proportions were included in coldspots in the hotspot analysis. For example, 60% to 80% of suicides were Alc+ in Manly and Carlingford in the greater Sydney area, and in Barwon – West, Ballarat and the Yarra Ranges in greater Melbourne. In future studies, more intricate clustering strategies may be required to adapt for the concentration of areas in urban Australia.

Finally, no statistical inferences can be made on relationships between factors reported on Alc+ suicides. Due to the population district being the unit of analysis, the interaction of risk factors within individuals cannot be explored. There are also many factors unaccounted for in this study that may influence Alc+ suicide events. This includes factors shown to be important such as existing suicide and alcohol prevention interventions, the availability of healthcare services and suicide contagion.

Although this study was interested in investigating the lifestyle/environment of the individual, future research may also like to consider applying similar research methods to the place of death rather than residence at the time of death. This may provide information regarding the acute factors involved in alcohol-related suicides.

Conclusion

This study has used density and hotspot cluster analysis techniques to identify areas that experience high proportions of Alc+ suicides. These results have significant applications in designing effective, area-specific individualised and population-based prevention strategies. Additionally, the results from this study establish areas of interest which, with further future research, will help to better understand the contextual features that increase proportions of Alc+ suicides in some regions.

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