Social Science and Medicine manuscript #: SSM-D-13-01284

Title:

Predictors of suicides occurring within suicide clusters in Australia, 2004-2008

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Acknowledgements

We thank the Department of Justice for providing us access to the database of coronial cases in the National Coroners Information System. We also thank Prof. David Studdert for providing useful comments on the methodology of this paper.

Abstract

A number of studies have investigated the presence of suicide clusters, but few have sought to identify risk and protective factors of a suicide occurring within a cluster. We aimed to identify socio-demographic and contextual characteristics of suicide clusters from national and regional analyses of suicide clusters. We searched the National Coroners Information System for all suicides in Australia between 2004-2008. Scan statistics were initially used to identify those deaths occurring within a spatial-temporal suicide cluster during the period. We then used logistic regression and generalized estimation equations to estimate the odds of each suicide occurring within a cluster differed by sex, age, marital status, employment status, Indigenous status, method of suicide and location. We identified 258 suicides out of 10,176 suicides during the period that we classified as being within a suicide cluster. When the deceased was Indigenous, living outside a capital city, or living in the northern part of Australia (in particular, Northern Territory, Queensland and Western Australia) then there was an increased likelihood of their death occurring within a suicide cluster. These findings suggest that suicide clustering might be linked with geographical and Indigenous factors, which supported sociological explanations of suicide clustering. This finding is significant for justifying resource allocation for tackling suicide clustering in particular areas.

Keywords: Australia; Suicide; Suicide clusters; Scan statistics; Indigenous suicides;

NCIS

Introduction

A growing number of countries recognize the importance of detecting and monitoring suicide clusters (Chang et al., 2010; Exeter & Boyle, 2007; Qi et al., 2010). Suicide clusters are defined by the occurrence of an exceptionally greater number of deaths by suicide than would be expected in an area and in a time period (Centers for Disease Control and Prevention, 1988; Cheung et al., 2013). From a suicide prevention perspective, the detection of suicide clusters is important as it potentially allows mental health professionals and other key service providers to be deployed to areas of high risk to intervene and prevent further death or harm (Gould et al., 1994).

Because suicide clusters are not observed directly – rather the presence is inferred on the basis that the number of deaths exceeds the expected number of deaths – studies have used different methods to detect the presence of suicide clusters. Some studies are based on qualitative observations of the relationship between the deceased (Austin et al., 2011b; Johansson et al., 2006); others used geo-statistical techniques to test statistically if cases are sufficiently close in space and time (Exeter & Boyle, 2007; Gould et al., 1994; Gould et al., 1990a; Gould et al., 1990b; Hourani et al., 1999; McKenzie et al., 2005; Qi et al., 2012; Taiminen & Helenius, 1994; Wissow et al., 2001). Regardless of the method used to identify the clusters, questions remain about the mechanisms that led to the formation of clusters.

Several explanations have been proposed, drawing heavily on psychological and sociological theories of behaviour. At the heart of these explanations is the concept of suicide contagion – defined as two or more suicide cases occurring in close proximity (in terms of social ties or contacts), such that one suicide can be the stimuli of others to “imitate” the suicidal act (Johansson et al., 2006; Taiminen, 1992). Contagion has been identified in most of the previous studies in this area as the mechanism of suicide clustering. (Daniel et al., 2006; De Leo & Heller, 2008; Gould et al., 1994; Insel & Gould, 2008; McKenzie et al., 2005; Naito, 2007; Pirkis & Blood, 2001; Shoval et al., 2005; Taiminen et al., 1998).

The notion that suicide can be imitated is consistent with Bandura’s social learning theory (Bandura, 1977), which seeks to explain how people observe other people’s behavior and imitate them. Applied to suicidal behaviour, the theory suggests that, when a person is exposed to a suicide model, he or she attends to the features of the modeled activities and a retention process then takes place such that the person decodes the model’s message and mentally rehearses the modeled behavior. Environmental stimuli then act to reinforce and motivate the individual to clarify specific previously learned behavior.

Others have offered explanations for suicide clustering that draw on sociological, rather than psychological, underpinnings. These explanations take into

account a broader consideration of the macro environment that leads to the clustering. From a sociological perspective, Durkheim's classical suicide theory has been referenced as the basis of why and how the suicide rate in a certain space and time period could be elevated (Durkheim, [1897]1951). In his own analysis of suicide, Durkheim did not suggest that suicide itself can be clustered and imitated. Rather, he suggested that the degrees of social integration and social regulation are essential factors to understanding suicide trends and patterns. He concluded that high suicide rates cluster in geographic space only because low social integration and regulation simultaneously cluster in the same space. The reason he suggested for this is that people living in an area with low levels of social regulation do not have strict norms and social ties to shield themselves from the hazard of modeling suicidal behaviors. As a result, if an individual experiences no regulation or control from either his or her family or from society, the tendency of suicide clustering is greater.

The prior condition hypothesis by Jonas (1992) is consistent with Durkheim's explanation. Jonas proposed that a confounding effect is present in the relationship of the two events. He stated that, instead of using one person's suicide as a cause of another, there could be another factor or effect acting between the index suicide and the modeled suicide (Jonas, 1992). Joiner (1999) similarly suggested that external influences could be an evident and observable agent for suicide clustering, as opposed

to the explanation suggested by the social learning theory. This suggests the possibility that people who complete suicide are clustered well before any overt suicidal stimulus. As a result, suicide clusters are an observed phenomena but the underlying (latent) reason might be the prior clustering of certain disadvantageous attributes. Several previous investigations into suicide clustering among those who have mental illnesses (McKenzie et al., 2005) and a history of vulnerability during adolescents (Poijula et al., 2001) are examples, which demonstrate a shared and elevated suicidal risk in a specific space or time, in which contagion between those who die by suicide may co-exist.

Several studies have examined the shared characteristics of members in suicide clusters to test these sociological explanations of suicide clustering. A Swedish study found that individuals in suicide clusters tended to belong to a stratum in society that was characterized by socio-demographic, personality and biological characteristics. These characteristics were referred to as “assortative susceptibility” by the author (Chotai, 2005). A Scottish study identified a number of spatial suicide clusters and found that those who died by suicide within the clusters were more likely to be economically deprived and to have died using a particular method (poisoning by liquids or solids) than those who died outside the cluster (Exeter & Boyle, 2007). A US study tested whether clustering of suicides could be accounted for by the clustering of risk factors (e.g., regions with high divorce rates or a high proportion of residents born

outside the country). The findings showed that clustering of suicide was significantly associated with social factors like lower marital stability, and lower residential stability (Baller & Richardson, 2002).

Taken together, these findings support Durkheim's theory of suicide in the sense that suicide clustering is inseparable from social structure and social quality. They imply that characteristics of suicide clusters are identifiable, and are able to reflect an underlying vulnerability in the community that precipitated the suicidal acts. Yet, improvements in the methodology can be made to sharpen the focus of these research findings. The term "cluster" in these studies was used in a relatively loose manner, and did not take account of both temporal and spatial dimensions. The study by Baller and Richardson (2002) analysed the spatial correlates of suicide clustering in areas with high suicide rates, so their results may not generalise to other populations (Baller & Richardson, 2002). In addition, instead of treating descriptively aggregated cases as clustered suicides, clustered suicide can be defined as cases with close proximity in time and space, which better captures the definition of suicide clustering. Chotai's (2005) analysis defined clustered suicides as those suicide cases that occurred in the months with unusually large numbers of suicide. This definition overlooked the patterns within a month and potential clusters in other months. Although individual-level data was used to avoid the ecological fallacy, the temporal manifestation could alter the conclusions

drawn about the clustering effect, i.e. the modifiable areal unit problem (Waller & Gotway, 2004).

In Australia, suicide clusters have been identified in individual states and territories – e.g., Queensland (Qi et al., 2010), the Northern Territory (Hanssens & Hanssens, 2007), and South Australia (Austin et al., 2011b). We previously used scan statistics to detect spatial-temporal clusters in Australia and found that they were located in the inland northern areas, with socio-economic deprivation and higher proportions of Indigenous people (Cheung et al., 2013). None of these studies looked at whether there were certain characteristics that might be common among members of suicide clusters. However, ascertaining if suicide clusters are comprised of individuals with characteristics in common is important for furthering knowledge about why clusters occur. Relatedly, our knowledge of the mechanisms that underpin the formation of suicide clusters is limited. Evidence from a small number of qualitative studies suggests that imitation occurs when there are links (direct or indirect) between members of the cluster and communication occurs across social networks (e.g., through direct contact or through social media) (Austin et al., 2011b; Hanssens, 2010). Exploration of the common correlates of the clustered suicides with a quantitative approach has the potential to tease out the influence of socio-demographic factors on suicide clustering.

In the current study, we aimed to test if clustered suicides, defined by a statistical

technique considering closeness in time and space, can be characterized by socio-demographics and contextual factors in accordance with sociological explanations of suicide clustering. In our previous study (Cheung et al., 2013), we identified a number of spatial-temporal clusters in Australia between 2004-2008. We used this information here to compare and contrast the socio-demographic and contextual characteristics of clustered and non-clustered suicide cases.

Methods

This study used a retrospective case-control design to investigate the characteristics of clustered suicides. As noted, it follows on from our previous study which sought evidence of spatial-temporal clustering of suicide in Australia (Cheung et al., 2013). A brief description of the data source and our statistical approach is provided here; further details are available in the earlier paper.

Ethics statement

The study was approved by the Human Research Ethics Committee of the Victorian Department of Justice.

Data

Archival data on completed suicides occurring from 2004-2008 in Australia were extracted from the National Coroners Information System (NCIS) – a database of all deaths investigated by Australian coroners (National Coroners Information System, 2010). The NCIS consists of a standardized set of coded and free text fields, uploaded from the coroners courts in each Australian state and territory. For each suicide case, the date of suicide incident and the postcode of usual residence were recorded. Among the 10,616 suicide cases available for analysis, 12 cases had postcodes that could not be matched with the postcodes in the digital boundary map file provided by Australian

Bureau of Statistics (ABS) and 82 cases had unidentified residence postcodes. For 346 of the remaining cases, the date of incident was not coded or was not known by the death investigators. As a result, 10,176 suicide cases (95.9%) with complete and reliable information about the location and date of incident were included in the study.

Population estimates for postcodes in 2006 were obtained from the 2006 census of the ABS. The most recent digitalized maps for each state/territory were contained in “2006 Census DataPacks” published by the ABS. These maps were merged with the ESRI ArcGIS (version 9.3) to form a digital boundary map file containing 2507 postcodes in Australia.

Identification of clustered suicide cases

Kulldorff’s scan statistics and the Poisson discrete model were applied to the data to detect spatial-temporal suicide clusters in Australia over the study period and to assess the significance of these clusters through Monte Carlo simulation (Kulldorff, 1997). These data were directly input into the SaTScan (version 9.0.1) program for conducting the scanning procedures and statistical tests to identify the specific locations and time period in which clustering occurred (Kulldorff, 2006; Kulldorff et al. 1995).

To remedy the possible selection bias of the scan statistics and because of unstable estimation due to the low case rate, we adopted a number of techniques to

reliably classify suicides into clustered and non-clustered cases (Chen et al., 2008). The maximum temporal window parameter was fixed at one, two and three months. For each value of the maximum temporal window, the maximum spatial window parameter was set from 1% to 50% of the population at risk. Therefore, no clusters were longer than 3 months in duration and the size of any cluster was not larger than an area with 50% of the population at risk. No finite geographical distance was set for the cluster detection, so there was no threshold of geographical distance of the clusters. All scan results were examined, and suicide cases within positive clusters (with more observed cases than expected cases) with a p-value less than 0.05 were classified as clustered suicides. In addition to scanning clusters across Australia as a whole, scan statistics were also applied in each state/territory separately so that both regional clusters and community-level clusters could be identified (Gregorio et al., 2006).

Predictors of clustering

Having identified the clustered suicide cases, we compared their basic socio-demographic and contextual characteristics with non-clustered suicide cases using logistic regression. The unit of analysis was each individual suicide. Suicide cases occurring within a cluster (in either the national analysis and/or the state/territory analysis) were classified as clustered suicides; all other suicides were coded as non-clustered suicides. We used all available variables in NCIS that previous research has

indicated may be associated with the risk of suicide. These were sex, age, marital status, employment status, Indigenous status, method of suicide and state/territory of residence of each suicide case. The remoteness level of the residence was referenced to the Rural, Remote and Metropolitan Areas (RRMA) classification, which divided all postcodes into seven ordinal categories (Department of Primary Industries and Energy & Department of Human Services and Health, 1994). State of residence was combined into five categories, comprising a category of those states with a low proportion of clustered suicides (Australian Capital Territory, New South Wales, Victoria and Tasmania), and individual categories for Western Australia, Northern Territory, South Australia and Queensland).

In analyzing the suicide data, the variables taken on suicide cases who lived in the same postcode are potentially “clustered”, which may have led to correlation among individuals within the same postcode. Such correlation should be taken into account to correctly estimate the standard errors of the regression parameters (Gordon & Stokes, 1996). Generalized Estimating Equation (GEE) is typically used to model correlated data for binary outcomes. As the suicides were clustered by postcodes, and there was no logical ordering for observations within a cluster, an exchangeable structure for the correlation matrix was adopted (Horton & Lipstiz, 1999).

We report the results from ordinary logistic regression (assuming independence

between all cases) and multivariate GEE modeling. For each model we report adjusted odds ratios (controlling for the effects of all other predictors in the model). We also examined interactions between Indigenous status and state/territory of residence and remoteness levels. We did this by creating new variables representing each Indigenous X state/territory and each Indigenous X remoteness level category. This approach is mathematically equivalent in entering main effect and interaction terms, but easier to interpret. We undertook post-hoc tests to compare the odds ratios for Indigenous and non-Indigenous by state/territory and remoteness. In all models, the Wald statistic was used to test the significance of each regression coefficient, and the joint-Wald test was used to assess the joint significance of the coefficients for multi-category variables.

Results

Scan statistics detected that 258 (2.5%) suicide cases were within significant spatial-temporal clusters of high relative risk. The suicide cases in these clusters were compared with the remaining 9,918 non-clustered suicides. From Table 1, those younger than 20 years (5.6%), Indigenous Australians (16.4%), and those living in the Northern Territory (18.0%), Queensland (5.7%), remote centres (12.6%), and other remote areas (21.2%) had exceptionally high proportions of clustered suicides. The ordinary logistic regression indicated that being of Indigenous origin (AOR=2.39, 95% CI 1.56-3.66) was associated with increased odds of being in a clustered suicide. Similarly, those who had resided in the Northern Territory (AOR=12.57, 95%CI 6.43-24.60), Queensland (AOR=10.30, 95% CI 6.38-16.61), Western Australia (AOR=4.04, 95% CI 2.22-7.34) and South Australia (AOR=7.36, 95% CI 4.02-13.49) – as opposed to the reference category (comprising Australian Capital Territory, New South Wales, Victoria and Tasmania) – had higher odds of being in a clustered suicide. Finally, in comparison to those living in capital cities, the odds of being in a clustered suicide was greater for those who had lived in rural (large rural centres, small rural centres and other rural centers) and remote areas (remote centres and other remote areas) were associated with clustered suicides.

From the GEE modeling, the joint-Wald statistics showed that the state/territory

and remoteness of the deceased were significant predictors of being a clustered suicide (Table 2). Suicides in Northern Territory (AOR=13.70, 95% CI 5.09-36.87), Queensland (AOR=7.98, 95% CI 3.93-16.19), Western Australia (AOR=3.75, 95% CI 1.64-8.58) and South Australia (AOR=5.70, 95% CI 2.34-13.91) had significantly greater odds of being clustered than those in reference states/territories. Individuals who lived in large rural centres (AOR=4.39, 95% CI 2.51-7.70), small rural centres (AOR=6.10, 95% CI 3.06-12.19), other rural areas (AOR=3.18, 95% CI 1.79-5.63), remote centres (AOR=5.94, 95% CI 2.46-14.34) and other remote areas (AOR=12.33, 95% CI 6.58-23.09) had a higher likelihood of being within clusters than those in capital cities. Indigenous status was not associated with clustered suicide in this model (AOR=1.61, 95% CI 0.90-2.86).

State/territory of residence and remoteness level of the residence were both significant predictors in the multivariate models, and Indigenous status was a significant predictor in the first multivariate model. Examining the interactions between these variables showed that the odds of Indigenous deaths being in a cluster varied by state/territory ($p < 0.01$) but not by remoteness level ($p = 0.75$). With respect to Indigenous status, post-hoc tests show that odds of an Indigenous person being in a cluster was greater in Western Australia (OR = 1.16 vs. 16.80, $p < 0.01$ for non-Indigenous and Indigenous respectively) and lower in Northern Territory (OR = 33.30

vs. 12.09, $p < 0.01$ for non-Indigenous and Indigenous respectively). There was no significant difference in the non-Indigenous and Indigenous odds for the other states. These results are illustrated in Figure 1, which shows the proportion of suicides in a cluster for all states by Indigenous status.

Discussion

The current study extends our previous research by identifying common correlates of clustered suicides, by comparing clustered suicides with non-clustered suicides using a statistical method that takes into account the within-postcode correlations. Suicide cases where the deceased lived in the Northern Territory, Queensland, South Australia and Western Australia were more likely than those living in other states/territories to be part of suicide clusters. There was evidence that Indigenous status and remoteness level were associated with clustered suicide, although the effect for Indigenous status may be modified by the state of residence. Compositional factors (age and Indigenous status) had only weak associations with being in a cluster. The association between a clustered suicide and rurality implies that people who were socio-economically deprived and lacked service and infrastructure provision were clustered in certain areas and hence suicides that occurred in those areas were more likely to be clustered. On the other hand, most individual factors were not associated with clustered suicide. People with vulnerabilities such as being unemployed and divorced were not more susceptible to suicide clustering, which was consistent with at least one previous study (Chotai, 2005). As the current study has explored very limited individual characteristics and suicide-related risk factors, the evidence to verify the mechanism of sociological explanation in suicide clustering is not confirmative. Nevertheless, the risk

factors for suicide clustering that were identified, favoured sociological explanations of suicide clustering. Other psycho-social vulnerabilities and environmental deprivation could be important risk factors for suicide clustering, and worthy of further exploration.

Our analysis suggests that geographical factors are closely related to suicide clustering. Suicides in less urban and more remote areas are more likely to occur within suicide clusters. The uneven spatial distribution of suicide clusters suggested that the risk of suicide clustering can be subject to social and environmental factors that may be location-related. In Australia, there are fewer employment options and higher unemployment in rural and remote areas than in metropolitan areas (Smith et al., 2008). There are differences across states and territories in terms of socio-economic circumstances, healthcare service provisions, and general health status (Australian Bureau of Statistics, 2007). Previous studies across Australia have revealed that a gradient of suicide risk exists across the states and territories in Australia (Large & Nielssen, 2010). Reduced rainfall or degraded soil conditions would adversely impact upon agricultural productivity and worsen the economic and emotional well-being of farmers living in these areas (Nicholls et al., 2006; Qi et al., 2009; Speldewinde et al., 2009). Rural people tended to migrate to urban areas where they can find more job opportunities (Alston, 2012; Judd et al., 2006). This is consistent with the other studies which suggest that living in a rural forested region is associated with clustering (Chotai,

2005) and that socio-economic deprivation also acts as a risk factor (Exeter & Boyle, 2007). Better access to mental health service should be provided to these states and rural and remote areas. Specifically, resources can be allocated for increasing number of medical personnel and facilities in these areas. More indicative interventions including care for suicidal persons and hotline service for crisis seeking for high-risk groups should be sustained (Robinson et al., 2006).

Our findings with respect to Indigenous status require careful consideration. Although a large proportion of Indigenous suicides fell within clusters, the effect was only found in Western Australia. The proportion of clustered suicides where the deceased was Indigenous was lower than non-Indigenous suicides in the Northern Territory, but the proportion was still higher than other states/territories. The association between Indigenous suicide and clustering became insignificant when the spatial correlation was taken into account, which suggests that clustered suicides located in neighbouring postcodes accounted for the excess risk of clustering in Indigenous suicides. These findings implied that the link between Indigenous suicide and suicide clustering in Australia should be interpreted cautiously, with the consideration of other possible explanations.

The high proportion of clustered cases in Indigenous suicides in Queensland, Northern Territory and Western Australia is of concern, and worth exploring further.

Indigenous people in Queensland have a suicide rate 2.2 times higher than non-Indigenous people, particularly among young people (De Leo et al., 2011). The number of Indigenous suicides each year in the Northern Territory has been increasing since 1980 (Measey et al., 2006). There may be various reasons for the elevated rates of Indigenous suicide, including, for example, conflicts between strong cultural values and urbanization (Booth, 2010). Some have suggested that Indigenous young people who experience discord with their families and low adaption of their cultural values are prone to greater risk of suicide (Else et al., 2007; MacNeil, 2008; Silviken et al., 2006). Because the suicide rate among Indigenous Australians is high, Indigenous people may have more exposure to suicidal behaviors than their non-Indigenous counterparts and this may put them at risk of imitative suicidal acts (Hanssens, 2011). There is some evidence from reviews of coronial files, that familial and filial contagion are observed in Indigenous suicide clusters because of the rapid reach of news regarding a suicide death in Indigenous community and their close-knit social network (Hanssens, 2011; Wissow et al., 2001). The association between Indigenous status and suicide clustering was particularly profound in Western Australia and remote regions. It is plausible that in these areas, the composite effect of contextual deprivation, greater proportions of indigenous people in the population, and the familial or filial interconnectedness among indigenous people may exacerbate the risk of suicide contagion (Speldewinde et al.,

2009). Further research is needed to understand the underlying mechanism.

Various countries, including Australia, have developed resources for communities to prevent and/or contain suicide clusters (Australian Government Department of Health and Ageing, 2012; Centers for Disease Control and Prevention, 1988). These resources are based on recognized best practice, but further evidence is required to strengthen the evidence base around cluster prevention and containment. A better understanding of suicide clustering and contagion is necessary to inform policy and resource allocation decisions. Our study indicates some of the factors that increase the likelihood of suicides occurring in clusters.

Limitations

Our study had a number of methodological issues, which must be acknowledged. Firstly, there are a number of limitations inherent in scan statistics, including ignoring other possible dimensions for determining clustering, the use of a cylindrical shape to scan for the location of clusters and the difficulties in using different sizes of postcodes (Cheung et al., 2013). These factors could lead to misclassification of some clustered suicides for the present study, although the extent of this misclassification bias is unknown.

Second, our conclusion about the risk factors for suicide clustering is based on an analysis, which collectively discriminate clustered suicides from non-clustered

suicide. It overlooked the specific characteristics of each cluster. Quantitative study of the homogeneousness of the within-cluster suicides, or psychological autopsy studies of individual clustered suicides may be needed to better understand the characteristics in more detail.

Third, the variable “Indigenous status” was not coded for about one fifth of the suicides in the NCIS database. This information can only be identified by descent and self-identification during the coronial processes (National Coroners Information System, 2007). The authors of a previous study commented that the missing Indigenous status of deaths may be due to insufficient evidence of cultural and racial background available at the time of autopsy (Austin et al., 2011a). For the purposes of the current study, we treated all uncoded suicides as non-Indigenous, but this may underestimate the proportion of Indigenous suicides and affect the results of regression models.

Lastly, the present study included only basic demographic and geographical factors as predictors. Other key variables related to suicide like exposure to a peer’s suicide, diagnosis of psychiatric illnesses and history of suicide attempt were contained in the case files but not available in the NCIS dataset. Future study of these areas is essential to understand the mechanisms that may underpin suicide clustering.

Conclusions

The findings from this study suggest that suicides by people who lived in rural

and remote areas or in the Northern Territory, Queensland, South Australia and Western Australia were more likely than those in other areas or states/territories to be part of a suicide cluster. Indigenous suicide in Northern Territory, Queensland and Western Australia had heightened risk of being clustered. Prevention strategies regarding suicide clustering should target these locations.

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Table 1: Clustered and non-clustered suicides: Descriptive statistics on socio-demographic characteristics and odds ratios from ordinary logistic regression

Variable	Category	% suicide cases within correlates		Ordinary logistic regression		
		Non-clustered (n=9918)	Clustered (n=258)	Adjusted odds ratios	Wald/ Join- statistics	p-value
Sex ^{##}	Female	97.7	2.3	1.07 (0.75, 1.53)	0.14	0.70
(Missing=0)	Male	97.4	2.6	1.00		
Age group	Below 20	94.4	5.6	1.95 (0.89, 4.28)	3.29	0.35
(Missing =2)	20-39	97.0	3.0	1.61 (0.91, 2.85)		
	40-59	98.0	2.0	1.40 (0.82, 2.39)		
	60 or above [#]	98.4	1.6	1.00		
Marital Status	Married [#]	97.1	2.9	1.00	3.62	0.61
(Missing=1,979)	Never Married	97.7	2.3	0.92 (0.64, 1.32)		
	Divorced	97.0	3.0	1.04 (0.57, 1.89)		
	Separated	97.9	2.1	0.95 (0.58, 1.58)		
	Widowed	99.7	0.3	0.18 (0.02, 1.38)		
	Unknown	98.0	2.0	0.82 (0.53, 1.25)		
Employment	Employed/Self-employed [#]	97.8	2.2	1.00	3.08	0.69
status	Unemployed	96.7	3.3	0.82 (0.57, 1.19)		
(Missing=1,052)	Retired/Pensioner	98.2	1.8	1.27 (0.77, 2.09)		
	Student	96.6	3.4	1.08 (0.52, 2.27)		
	Home Duties	98.1	1.9	0.95 (0.32, 2.84)		
	Others [†]	96.3	3.7	1.12 (0.74, 1.70)		
Indigenous	Yes	83.6	16.4	2.39 (1.56, 3.66)	16.17	p<0.01
origin ^{##}	No	98.1	1.9	1.00		
(Missing=1,928)						
Primary suicide	Hanging [#]	96.8	3.2	1.00	8.12	0.62
method	Carbon monoxide poisoning	97.3	2.7	1.48 (0.97, 2.25)		
(Missing=327)	Drug poisoning	98.1	1.9	0.98 (0.60, 1.60)		
	Firearm	96.5	3.5	1.06 (0.67, 1.69)		
	Transport injury	99.7	0.3	0.19 (0.03, 1.35)		
	Falling from height	99.0	1.0	0.84 (0.32, 2.16)		
	Drowning	98.3	1.7	0.92 (0.28, 3.07)		
	Fire or burn	98.4	1.6	0.64 (0.15, 2.74)		
	Cutting or stabbing	98.6	1.4	0.89 (0.27, 2.92)		
	Other ways of obstruct breathing	98.2	1.8	1.20 (0.42, 3.44)		
	Others	99.0	1.0	0.51 (0.06, 3.99)		
State/territory of	ACT [#]	98.7	1.3	1.00	105.86	p<0.01
residence	NSW [#]	100.0	0.0	1.00		
(Missing=0)	VIC [#]	99.2	0.8	1.00		
	TAS [#]	100.0	0.0	1.00		
	QLD	94.3	5.7	10.30 (6.38, 16.61)		
	SA	97.0	3.0	7.36 (4.02, 13.49)		
	NT	82.0	18.0	12.57 (6.43, 24.60)		
	WA	97.3	2.7	4.04 (2.22, 7.34)		
RRMA	M1 [#]	99.2	0.8	1.00	109.62	p<0.01
classification	M2	98.6	1.4	1.25 (0.63, 2.46)		
(Missing=0)	R1	95.3	4.7	3.91 (2.42, 6.31)		
	R2	95.7	4.3	4.79 (2.91, 7.91)		
	R3	95.8	4.2	3.95 (2.62, 5.93)		
	Rem1	87.4	12.6	6.42 (3.59, 11.45)		
	Rem2	78.8	21.2	10.82 (6.50, 18.01)		

Remark:

Percentages shown are row percentages

#Reference group

##When there is only one parameter for a categorical variable, the joint Wald test is the same as the Wald test.

*The odds ratio represent the increased in odds for being suicide deceased resided in ACT, VIC, NSW and TAS.

†Others of employment status included children not in school, prisoners and those whose employment status were not known

ACT: Australian Capital Territory, NSW: New South Wales, VIC: Victoria, QLD: Queensland, SA: South Australia, WA: Western Australia, TAS: Tasmania, NT: Northern Territory

M1: Capital cities, M2: Other metropolitan centres, R1: Large rural centres, R2: Small rural centres, R3: Other rural areas, Rem1: Remote centres, Rem2: Other remote areas

Table 2: Adjusted odds ratios for clustered suicides from Generalized Estimating Equation modeling

Generalized Estimating Equation modeling				
Variable	Category	Adjusted odds ratio	Joint-Wald statistics ^{##}	p-value
Sex	Female	1.09 (0.76 ,1.58)	0.23	0.63
	Male [#]	1.00		
Age group	Below 20	1.86 (0.79 ,4.36)	2.01	0.16
	20-39	1.35 (0.74 ,2.46)		
	40-59	1.21 (0.69 ,2.14)		
	60 or above [#]	1.00		
Marital Status	Married [#]	1.00	4.17	0.53
	Never Married	0.92 (0.59 ,1.45)		
	Divorced	1.09 (0.61 ,1.93)		
	Separated	0.92 (0.52 ,1.61)		
	Widowed	0.19 (0.03 ,1.38)		
	Unknown	0.76 (0.47 ,1.21)		
Employment status	Employed/Self-employed [#]	1.00	2.94	0.71
	Unemployed	0.76 (0.53, 1.11)		
	Retired/Pensioner	1.09 (0.63, 1.87)		
	Student	0.92 (0.40, 2.10)		
	Home Duties	1.01 (0.27, 3.75)		
	Others [†]	1.01 (0.65, 1.56)		
Indigenous origin	Yes	1.61 (0.90, 2.86)	2.59	0.11
	No [#]	1.00		
Primary suicide method	Hanging [#]	1.00	9.88	0.45
	Carbon monoxide poisoning	1.57 (1.01 ,2.43)		
	Drug poisoning	1.17 (0.70 ,1.97)		
	Firearm	1.04 (0.61 ,1.78)		
	Transport injury	0.29 (0.06 ,1.32)		
	Falling from height	0.84 (0.30 ,2.33)		
	Drowning	0.85 (0.23 ,3.20)		
	Fire or burn	0.84 (0.24 ,2.96)		
	Cutting or stabbing	1.09 (0.33 ,3.57)		
	Other ways of obstruct breathing	1.25 (0.36 ,4.36)		
	Others	0.69 (0.12 ,3.91)		
State/territory of residence	ACT, NSW, VIC & TAS [#]	1.00	39.02	p<0.01
	QLD	7.98(3.93,16.19)		
	SA	5.70(2.34,13.91)		
	NT	13.70(5.09,36.87)		
	WA	3.75(1.64,8.58)		
RRMA classification	M1 [#]	1.00	74.28	p<0.01
	M2	0.97 (0.28 ,3.34)		
	R1	4.39 (2.51 ,7.70)		
	R2	6.10 (3.06 ,12.19)		
	R3	3.18 (1.79 ,5.63)		
	Rem1	5.94 (2.46 ,14.34)		
	Rem2	12.33 (6.58 ,23.09)		

Remark:

[#]Reference group

^{##}When there is only one parameter for a categorical variable, the joint Wald test is the same as the

Wald test.

†Others of employment status included children not in school, prisoners and those whose employment status were not known

ACT: Australian Capital Territory, NSW: New South Wales, VIC: Victoria, QLD: Queensland, SA: South Australia, WA: Western Australia, TAS: Tasmania, NT: Northern Territory

M1: Capital cities, M2: Other metropolitan centres, R1: Large rural centres, R2: Small rural centres, R3: Other rural areas, Rem1: Remote centres, Rem2: Other remote areas

Table 3: Adjusted odds ratios of the interactions between state/territory of residence and Indigenous origin, and between RRMA classification and Indigenous origin for clustered suicides from Generalized Estimating Equation modeling

Variable	Category	Generalized Estimating Equation modeling				
		Adjusted odds ratio	Wald statistics	p-value	Post-hoc test (interaction)	p-value
State/territory of residence and Indigenous origin	ACT, NSW, VIC & TAS [#]	1.00				
	QLD non-indigenous	7.92(3.92,15.99)	5.77	<0.01	1.73	0.19
	QLD indigenous	12.97(4.75,35.46)	5.00	<0.01		
	SA non-indigenous	5.66(2.32,13.78)	3.81	<0.01	0.15	0.70
	SA indigenous	4.34(0.94,20.16)	1.88	0.06		
	WA non-indigenous	1.16(0.37,3.58)	0.26	0.80	11.47	<0.01
	WA indigenous	16.80(5.30,53.26)	4.79	<0.01		
	NT non-indigenous	33.30(14.51,76.39)	8.27	<0.01	8.24	<0.01
RRMA classification and Indigenous origin	NT indigenous	12.09(4.80,30.42)	5.29	<0.01		
	M1 non-indigenous [#]	1.00				
	M1 indigenous	0.37(0.02,7.55)	0.57	0.52		
	M2 non-indigenous	0.86(0.29,2.62)	0.49	0.80	0.26	0.61
	M2 indigenous	2.45(0.02,259.03)	5.83	0.71		
	R1 non-indigenous*	4.61(2.64,8.02)	1.30	<0.01		
	R2 non-indigenous	5.86(2.92,11.79)	2.09	<0.01	2.02	0.16
	R2 indigenous	9.25(3.97,21.53)	3.99	<0.01		
	R3 non-indigenous	3.12(1.76,5.56)	0.92	<0.01	0.09	0.77
	R3 indigenous	3.77(1.00,14.12)	2.54	0.05		
	Rem1 non-indigenous	5.46(2.64,11.3)	2.03	<0.01	0.59	0.44
	Rem1 indigenous	9.90(1.96,50.10)	8.19	<0.01		
	Rem2 non-indigenous	8.26(3.90,17.47)	3.16	<0.01	4.15	0.04
	Rem2 indigenous	27.4(10.24,73.33)	13.76	<0.01		

Remark:

[#]Reference group

*The R1 indigenous group was omitted from the regression model because the number of cluster suicides in the category was zero.

Adjusting variables: Sex, age group, marital status, employment status and suicide methods

ACT: Australian Capital Territory, NSW: New South Wales, VIC: Victoria, QLD: Queensland, SA: South Australia, WA: Western Australia, TAS: Tasmania, NT: Northern Territory

M1: Capital cities, M2: Other metropolitan centres, R1: Large rural centres, R2: Small rural centres, R3: Other rural areas, Rem1: Remote centres, Rem2: Other remote areas

Figure 1: Percentage of clustered suicides among indigenous and non-indigenous suicides by state/territory of residence

Figure 2: Percentage of clustered suicides among indigenous and non-indigenous suicides by RRMA