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Understanding the characteristics and mechanisms underlying suicide clusters in Australian youth: a comparison of cluster detection methods

Original Article

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Author for correspondence:
Nicole T.M. Hill, E-mail: nicole.hill@telethonkids.org.au

N.T.M. Hill[1,2], L.S. Too[3], M.J. Spittal[3] and J. Robinson[1]

[1]Orygen, Centre for Youth Mental Health, University of Melbourne, Melbourne, Australia; [2]Telethon Kids Institute, Perth, Australia and [3]Centre for Mental Health, Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia

Abstract

Aims. There is currently no gold-standard definition or method for identifying suicide clusters, resulting in considerable heterogeneity in the types of suicide clusters that are detected. This study sought to identify the characteristics, mechanisms and parameters of suicide clusters using three cluster detection methods. Specifically, the study aimed to: (1) determine the overlap in suicide clusters among each method, (2) compare the spatial and temporal parameters associated with different suicide clusters and (3) identify the demographic characteristics and rates of exposure to suicide among cluster and non-cluster members.

Methods. Suicide data were obtained from the National Coronial Information System. $N = 3027$ Australians, aged 10–24 who died by suicide in 2006–2015 were included. Suicide clusters were determined using: (1) poisson scan statistics, (2) a systematic search of coronial inquests and (3) descriptive network analysis. These methods were chosen to operationalise three different definitions of suicide clusters, namely clusters that are: (1) statistically significant, (2) perceived to be significant and (3) characterised by social links among three or more suicide descendants. For each method, the demographic characteristics and rates of exposure to suicide were identified, in addition to the maximum duration of suicide clusters, the geospatial overlap between suicide clusters, and the overlap of individual cluster members.

Results. Eight suicide clusters (69 suicides) were identified from the scan statistic, seven (40 suicides) from coronial inquests; and 11 (37 suicides) from the descriptive network analysis. Of the eight clusters detected using the scan statistic, two overlapped with clusters detected using the descriptive network analysis and one with clusters identified from coronial inquests. Of the seven clusters from coronial inquests, four overlapped with clusters from the descriptive network analysis and one with clusters from the scan statistic. Overall, 9.2% (12 suicides) of individuals were identified by more than one method. Prior exposure to suicide was 10.1% ($N = 7$) in clusters from the scan statistic, 32.5% ($N = 13$) in clusters from coronial inquest and 56.8% ($N = 21$) in clusters from the descriptive network analysis.

Conclusion. Each method identified markedly different suicide clusters. Evidence of social links between cluster members typically involved clusters detected using the descriptive network analysis. However, these data were limited to the availability information collected as part of the police and coroner investigation. Communities tasked with detecting and responding to suicide clusters may benefit from using the spatial and temporal parameters revealed in descriptive studies to inform analyses of suicide clusters using inferential methods.

Introduction

Suicide clusters involve multiple suicides that occur closer in time or place than would normally be expected using statistical inference or community expectation (Hawton *et al.*, 2019). However, multiple suicides that are connected socially are also taken very seriously and are included in recent public health guidelines for responding to suicide clusters (Public Health England, 2015; Palmer *et al.*, 2018; Public Health England, 2019). Young people aged 10–24 years are two to four times more likely to be involved in a suicide cluster, compared to adults in the general population (Gould *et al.*, 1990*b*; Robinson *et al.*, 2016). Whilst early studies suggest between 1 and 13% of suicides in young people occur as part of a suicide cluster (Gould *et al.*, 1990*b*), recent estimates range between 5.2 and 57% (Robertson *et al.*, 2012; Cheung *et al.*, 2013; Robinson *et al.*, 2016). However, these differences appear to depend largely on the type of parameters and methods used to detect suicide clusters.

To date, several high income countries have implemented surveillance systems for the detection of suicide clusters (Clinical Advisory Services Aotearoa, 2016; Griffin *et al.*, 2017;

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Public Health England, 2020) as well as public health guidelines for the response and prevention of suicide clusters in the community (Centers for Disease Control, 1988; Health Service Executive (HSE), 2011; Centre for Health Policy Programs and Economics, 2012; Public Health England, 2015; Palmer *et al.*, 2018; Public Health England, 2019). Yet, despite significant public health investment, there is currently no gold-standard definition or method for detecting suicide clusters (Niedzwiedz *et al.*, 2014). For example, existing public health guidelines define a suicide cluster on the basis of both statistical inference and community expectation and note that suicide clusters may or may not involve social links between cluster members (Centers for Disease Control, 1988; Health Service Executive (HSE), 2011; Centre for Health Policy Programs and Economics, 2012; Public Health England, 2015; Palmer *et al.*, 2018; Public Health England, 2019).

The absence of a gold-standard definition of suicide clusters has resulted in considerable methodological heterogeneity in the way suicide clusters are operationalised and detected. For example, early studies of suicide clusters described the relationships between suicide descendants and found that many cluster members shared social links as friends or acquaintences (Bechtold, 1988; Davidson *et al.*, 1989; Wilkie *et al.*, 1998; Poijula *et al.*, 2001; Wissow *et al.*, 2001). This led to the common cited hypothesis that suicide contagion, more accurately known as the social transmission of suicidal behaviour (whereby exposure to suicide facilitates suicidal behaviour in others), is a key mechanism underlying the development of suicide clusters (Hawton *et al.*, 2019).

In the past two decades, there has been a methodological shift from descriptive studies of suicide clusters to inferential methods such as Poisson scan statistics. These studies used population data from suicide registries combined with geoinformation systems to determine whether suicides are greater than statistically expected within a particular time and place (Gould *et al.*, 1990*a*; Williamson *et al.*, 2014; Robinson *et al.*, 2016; Sy *et al.*, 2019). Whilst early descriptive studies of suicide clusters were reported in small community settings such as a schools (Poijula *et al.*, 2001), inpatient units (Taiminen *et al.*, 1998) and remote indigenous communities (Bechtold, 1988; Wilkie *et al.*, 1998; Wissow *et al.*, 2001), the shift towards inferential studies of suicide clusters has established the presence of suicide clusters in large nationwide studies (Gould *et al.*, 1990*a*, *b*; Cheung *et al.*, 2012; Jones *et al.*, 2013; Williamson *et al.*, 2014; Robinson *et al.*, 2016; Sy *et al.*, 2019).

Despite being methodologically very different, evidence from both descriptive and inferential studies of suicide clusters are often treated as synonymous. For example, population-based studies of suicide clusters suggest that the close temporal and spatial proximity of suicides within a suicide cluster are a proxy measure of social contiguity among cluster members (Gould *et al.*, 1990*a*, *b*; Robinson *et al.*, 2016; Sy *et al.*, 2019). However, the ecological design of these studies means that it is unclear whether individuals were actually exposed to the suicide of another or shared social links with cluster members. Significant differences in the size and duration of suicide clusters are also evident between methods. Descriptive studies of suicide clusters range between 2 and 11 suicides over a maximum 5-year period (Niedzwiedz *et al.*, 2014). In contrast, suicide clusters reported using the scan statistic range between 3 and 1500 suicides over a maximum to 2.5-year period (Cheung *et al.*, 2013; Robinson *et al.*, 2016; Sy *et al.*, 2019). In some instances, inferential studies have identified suicide clusters that span multiple states and territories (Cheung *et al.*, 2013; Robinson *et al.*, 2016; Sy *et al.*, 2019).

Distinguishing between the outcomes of different cluster detection methods has important implications for informing the way that communities detect suicide clusters. For example, previous studies of suicide clusters using the scan statistic have selected specific spatial and temporal parameters based on the size and duration of clusters reported in descriptive studies (Robinson *et al.*, 2016; Sy *et al.*, 2019). However, since descriptive studies have typically involved small community settings, it is unclear whether the spatio-temporal parameters used to guide inferential studies of suicide clusters are generalisable to broader populations and settings. Furthermore, distinguishing between suicide clusters which involve exposure to suicide, or links between cluster members, has the potential to improve a community's response to suicide clusters. Arguably, suicide clusters which involve social links between suicide descendants, may warrant different interventions and preventative approaches compared to those which involve no apparent links between cluster members.

This study sought to identify the characteristics and mechanisms of suicide clusters using three different, but common cluster detection methods, namely, the scan statistic, coronial inquests into suicide clusters and descriptive network analysis. These methods were chosen in order to operationalise the different definitions of suicide clusters, including those which are statistically significant, those which are significant to communities and those which involve social links among cluster members. Using the same nationwide data we aimed to: (1) determine the overlap between suicide clusters for each cluster detection method, (2) compare the spatial and temporal parameters associated with suicide clusters and (3) identify the demographic characteristics and prior of exposure to suicide among cluster and non-cluster members.

Methods

Data source and case ascertainment

The study was approved by the Justice Department Human Research Ethics Committee (CF/15/13188). Youth suicides were identified in the National Coronial Information System (NCIS). The NCIS is an online database that records external causes of death in Australia. Each death in the NCIS is accompanied by an individual case number which is linked to a set of core demographic variables including age, sex, indigenous status, employment status, marital status, date of death and location of death (Saar *et al.*, 2017). Additional data sources in the NCIS include narrative text from police reports, coroner's reports (including inquest findings), autopsy reports and toxicology findings.

The following cases were included in the analysis: (1) the case was closed and the cause of death was determined as suicide (recorded as intentional self-harm by the coroner), (2) the person was aged between 10 and 24 years at the time of their death and (3) the death occurred in Australia between 1 January 2006 and 31 December 2015 ($N = 3365$). The year 2015 was selected as the study endpoint because over 90% of suicides from this time period were closed and therefore fully investigated by the coroner (National Coroners Information System, 2019). A case was excluded if: (1) the death occurred outside Australia, (2) the cause of death was undetermined or (3) the case did not include at least one coroner or police report ($N = 93$). Finally, suicides which occurred in the state of South Australia ($N = 245$) were excluded due to the limited availability of narrative texts

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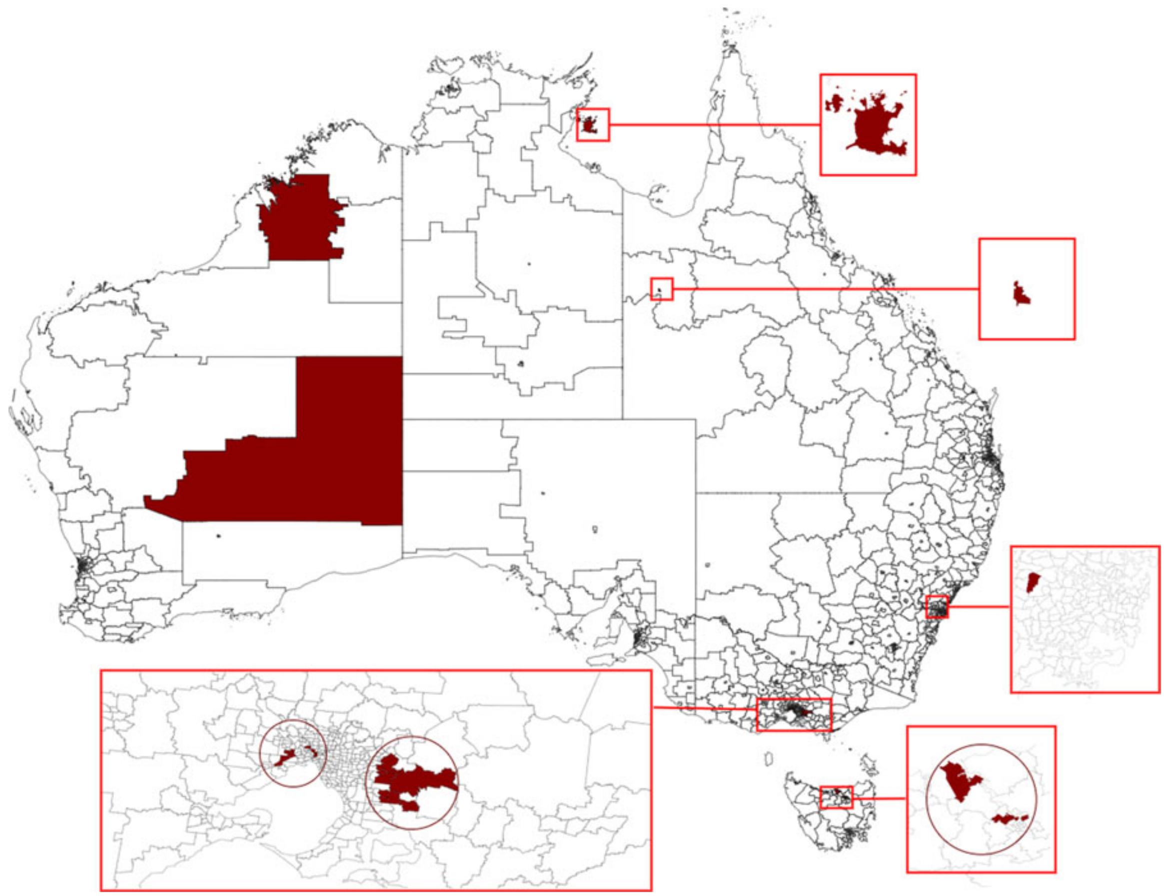

Fig. 1. Geographical locations of suicide clusters identified in Australian youth in 2006-2015 using the scan statistic. Geographic regions are based on Statistical Area 2 geographies (red). The circles represent a group of SA2s involved in a single cluster. All suicide clusters that were detected using the scan statistic were limited to a 100 km radius but are visualised using entire SA2 boundaries.

in police and coroner reports. As a result, a total of 3027 cases were included in the analyses.

Methods for detecting suicide clusters

The scan statistic

The scan statistic was used to identify suicide clusters that were statistically significant using inferential methods. The space-time scan statistic was used to identify the presence of spatio-temporal suicide clusters in Australia using the software SaTScan version 9.4.4. (Kulldorff, 2006). Each suicide was acquired at the individual level and aggregated by the month of death and SA2. The 2011 Australian standard population (the midpoint of our study period) was used to estimate age-adjusted rates of suicide in young people aged 10–24 years. Population estimates were recorded for each SA2 from the 2011 Estimated Resident Population recorded by the Australian Bureau of Statistics.

The Poisson discrete scan statistic was used to detect high relative rates of suicide incidence and was conducted separately in each state and territory. The likelihood of each possible cluster was assessed using Monte Carlo simulations. Consistent with previous studies (Robinson *et al.*, 2016), the minimum time window was set at seven days to a maximum of 730 days (two years) and the maximum spatial window at 10% of the population at risk with a maximum radius of 100 km (Jones *et al.*, 2013). This resulted in a set of cylindrical scanning windows where the base represents the area of the suicide cluster and the height represents the duration of the cluster. Clusters were included if their p value was <0.10 to account for the statistically rare incidence of suicides (Too *et al.*, 2017). Clusters are referred to as 'possible clusters' in the $0.10 < p < 0.05$ range and 'clusters' if $p < 0.05$.

Coroner inquests into suicide clusters

Coroner inquests into suicide clusters were used to identify suicide clusters that were perceived to be significant by communities that had experienced multiple suicides. A custom query was built to identify all cases where the cause of death was intentional self-harm and the term 'cluster' or 'contagion' was included in the coroner reports. No limitations were placed on the distance or duration between suicides included in a coronial inquest. A case was identified as a cluster member if it was included in a coronial inquest into a suicide cluster in Australia during the study period. A case was excluded if: (1) the term 'cluster' did not refer to a cluster of suicidal behaviour (e.g. 'Cluster B personality traits') or (2) the suicide did not meet the eligibility criteria for included cases in the NCIS outlined above. A total of 55 case records were identified in the initial search and were manually inspected by the first author (N.T.M.H) for cluster membership. A total of seven independent coronial inquests into suicide clusters were identified, encompassing 40 individuals who died by suicide. Further details on the case ascertainment of cluster members is provided in S1 Methods in the supplement.

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Table 1. Characteristics of suicide clusters detected using the scan statistic, coronial inquests and descriptive network analysis of social linked clusters

Cluster location	Year	Cluster duration N (days)	SA2 areas[a] N	Observed cases N	Exposed to suicide N (%)	Geographic overlap[b]	Spatial congruence[c] N (%)	Overlapping persons[d] N (%)	Geographic overlap[b]	Spatial congruence[c] N (%)	Overlapping persons[d] N (%)
A. The scan statistic						**Comparison A–B**			**Comparison A–C**		
New South Wales	2013	125	1	6	1 (16.7)	None	.	.	None	.	.
Northern Territory	2013	6	1	3	1 (33.3)	None	.	.	None	.	.
Queensland	2014	713	1	10	1 (10)	None	.	.	None	.	.
Tasmania	2010–2012	62	4	5	0 (0)	None	.	.	None	.	.
Victoria	2015	314	8	20	2 (10)	Partial	2 (25)	2 (10)	Partial	3 (37.5)	3 (15)
Victoria	2011–2012	62	7	10	2 (20)	None	.	.	None	.	.
Western Australia	2011–2013	725	1	12	0 (0)	None	.	.	None	.	.
Western Australia	2015	10	1	3	0 (0)	None	.	.	None	.	.
Total		252.13 (304.1)[e]	24	69	7 (10.1)		2 (8)	2 (3)		3 (12.5)	3 (4.3)
B. Coronial inquests						**Comparison B–C**			**Comparison B–A**		
Queensland	2007–2008	387	4	4	2 (50)	Partial	3 (75)	3 (75)	None	.	.
Queensland	2014–2014	121	3	3	3 (100)	None	.	.	None	.	
Victoria	2009	224	3	5	2 (40)	Partial	1 (33)	3 (60)	None	.	.
Victoria	2011–2012	446	8	8	2 (25)	Partial	4 (50)	4 (50)	partial	2 (25)	2 (25)
Western Australia	2006–2007	433	2	6	0 (0)	None	.	.	None	.	.
Western Australia	2008–2009	374	2	4	1 (25)	None	.	.	None	.	.
Western Australia	2012–2015	914	3	10	3 (30)	None	.	.	None	.	.
Total		414.14 (250.2)[e]	25	40	13 (32.5)		8 (32)	10 (25)		2 (8)	2 (5.0)
C. Descriptive network analysis						**Comparison C–B**			**Comparison C–A**		
New South Wales	2008–2010	549	2	3	1 (33.3)	None	.	.	None	.	.
New South Wales	2009–2013	1626	2	3	2 (66.7)	None	.	.	None	.	.
New South Wales	2011–2014	1201	2	4	2 (50)	None	.	.	None	.	.
Northern Territory	2012–2014	767	1	4	1 (25)	None	.	.	None	.	.
Queensland	2008	118	4	4	3 (75)	Partial	3/4 (75)	3/4 (75)	None	.	.
Queensland	2008	219	3	3	1 (33.3)	None	.	.	None	.	.
Queensland	2013	67	2	3	1 (33.3)	None	.	.	None	.	.
Queensland	2015	95	4	4	3 (75)	None	.	.	None	.	.
Victoria	2009	134	1	3	2 (66.7)	Full	1/1 (100)	3/3 (100)	None	.	.

Victoria	2011–2012	226	3	3	2 (66.7)	Partial	2/3 (66)	2/3 (66)	Partial	1 (33)	1 (33)
Victoria	2011	31	3	3	2 (66.7)	Partial	2/3 (66)	2/3 (66)	Partial	1 (33)	1 (33)
Total		457.6 (530.9)[e]	27	37	20 (52.6)		8 (30)	10 (27)		2 (7)	2 (5)

SA2, Australian Statistical Geography Standard – Statistical Area Level 2; S.D., standard deviation.
[a]The number of SA2s (per cluster).
[b]Complete (100% overlap among individuals and SA2s), partial (<100 overlap between cluster members and SA2s), none (no overlap between cluster members and SA2s).
[c]The number and proportion of SA2s that overlap (per cluster).
[d]The number and proportion of individuals that overlap (per cluster).
[e]Mean (S.D.).

Descriptive network analysis

Descriptive network analysis was used to identify suicide clusters that comprised social links between three or more suicide descendants (Larkin and Beautrais, 2012; Public Health England, 2015). The narrative text from police and coroner's reports was examined for evidence of social links between suicide descendants. Cases were linked if: (1) the young person was known to have been exposed to the suicide of another young person (e.g. they knew a friend who died by suicide; or they knew a peer from their school who died by suicide), (2) the police or coroner report referred to the first and last name of the person who previously died by suicide (the index case), (3) the police or coroner report referred to the date of death (e.g. month and year) and described at least one other characteristic that could identify the index case based on information included in the case records (e.g. the name of the school) and (4) There was evidence of social links between at least three or more individuals who died by suicide. No limitations were placed on the distance or duration between linked cases. A case was not linked and included in the network analysis if: (1) the police or coroner's report did not provide sufficient information on the index suicide death(s) or did not sufficiently match an eligible case in the NCIS, or (2) the suicide did not meet the eligibility criteria for included cases in the NCIS outlined above. Further details on the case ascertainment of linked cases are provided in S1 Methods in the supplement.

Comparison of cluster detection methods

Cluster membership was analysed as a binary variable representing the presence or absence of the outcome (cluster and non-cluster membership). Location of death was based on Statistical Area Level 2 (SA2) recorded in the NCIS. SA2s are general-purpose areas which represent communities that interact socially and economically. They represent a population range of 3000–25 000 persons and have an average population of ~10 000 persons (Australian Bureau of Statistics, 2018).

The comparison of cluster detection methods included: (1) the duration of the suicide cluster (the period of time between the index and last suicide death in the cluster), (2) the proportion of geospatial overlap between cluster detection methods (e.g. the number of suicide clusters that were detected by more than one method), (3) the spatial congruence between overlapping clusters (e.g. the proportion of SA2 spatial units that were identified within overlapping clusters) and (4) the number of overlapping cluster members (e.g. the number of individual cluster members that were identified by more than one cluster method).

The characteristics of cluster members were identified using the core demographic variables in the NCIS (age, sex, indigenous status, employment status, date of death, location and manner of death). Evidence of prior exposure to suicide was recorded for each case based on information recorded in the police and/or coroner's reports (e.g. family history of suicide or the death of a friend, peer or colleague). Differences between cluster and non-cluster members were compared using Pearson's chi-square test of independence. Fisher's exact probability test was employed when over 20% of cells had expected counts <5. All analyses, with the exception of the scan statistic, were conducted using R version 3.6.2. The geocode function of the ggmap package was used to identify the geocoordinates of each SA2 and to visualise the location of suicide clusters for each cluster detection method.

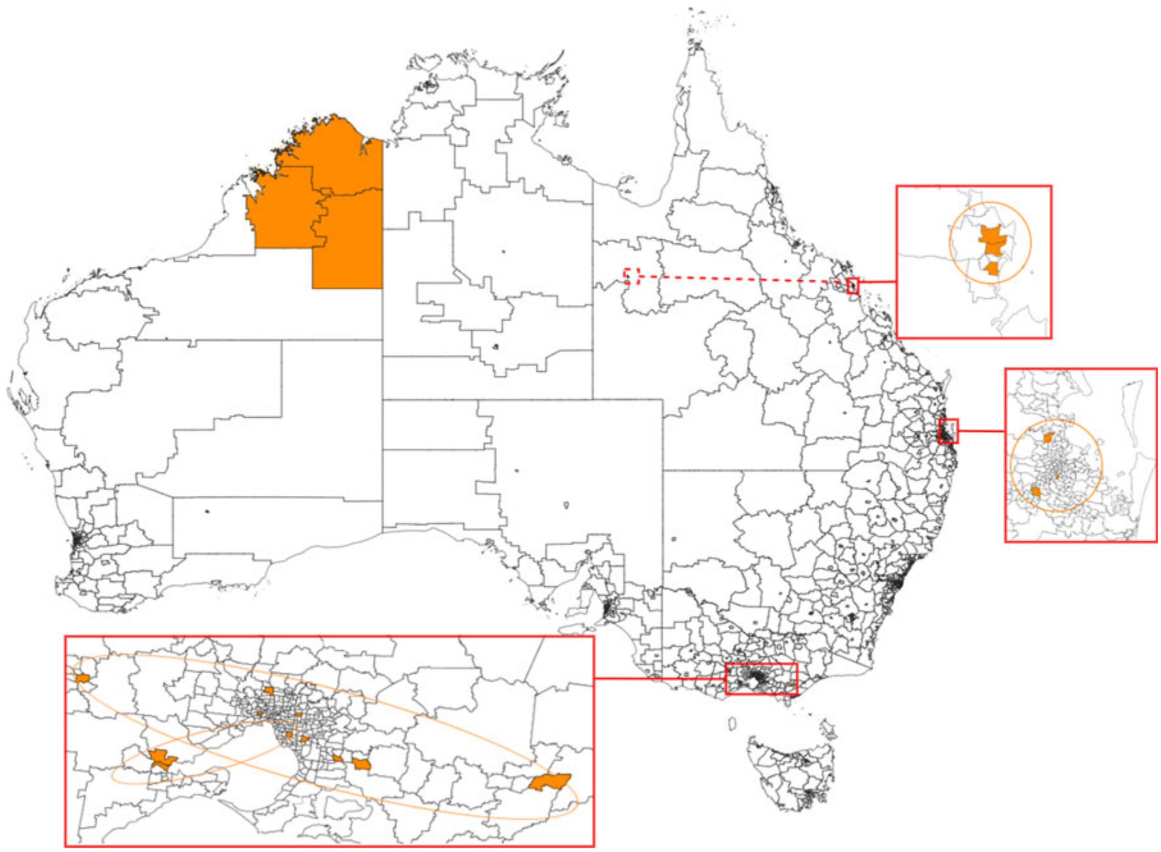

Fig. 2. Geographical locations of suicide clusters identified in Australian youth in 2006–2015 using information from coronial inquests into suicide clusters. Geographic regions are based on Statistical Area 2 geographies (orange). The circles represent a group of SA2s involved in a single coronial inquest.

Results

Characteristics of suicide clusters

The scan statistic

Eight spatial–temporal clusters of high relative risk were detected in six Australian states and territories (Fig. 1). A total of 69 young people were identified as cluster members, accounting for 2.3% of suicides. The number of individual's involved in a single suicide cluster ranged between 3 and 20 and the duration of each suicide cluster ranged between 6 and 725 days (Table 1). Cluster members were more likely than non-cluster members to be from Aboriginal and Torres Strait Islander origins and to reside in a remote or very remote location. Evidence of prior exposure to suicide was reported among 10.1% (7/69) of cluster members compared to 6.6% (195/2958) of non-cluster members but this difference was non-significant ($p = 0.38$). The remaining demographic characteristics were comparable among cluster and non-cluster members (online Supplementary Table S4).

Coronial inquests

Seven coronial inquests into suicide clusters were detected in three Australian states and territories (Fig. 2). A total of 40 young people were identified as cluster members, accounting for 1.3% of suicides. Six out of seven suicide clusters were described as being greater than expected on the basis of statistical inference and one suicide cluster involved social links between cluster members in an inpatient unit. The number of individuals involved in a single suicide cluster ranged between 3 and 8 and the duration of each suicide cluster ranged between 121 and 914 days (Table 1). Cluster members were more likely to be aged 18 years or less (70%, 28/40) compared to non-cluster members (29.7%, 887/2987, $p < 0.01$) and were more likely to be from Aboriginal and Torres Strait Island origins (55 *v.* 14.6% $p < 0.01$), and residing in a remote location at the time of death (50 *v.* 7.20%, $p < 0.01$). Evidence of prior exposure to suicide was reported among 32.5% (14/40) of cluster members compared to 6.43% (192/2990) of non-cluster members and this difference was statistically significant ($p < 0.001$). The remaining demographic characteristics were comparable among cluster and non-cluster members (online Supplementary Table S5).

Descriptive network analysis

Eleven suicide clusters comprising seven triads and four tetrads were detected in four Australian states and territories (Fig. 3). A total of 37 young people were identified as cluster members, accounting for 1.3% of suicides. The number of individuals involved in a single suicide cluster ranged between 3 and 4 and the duration of each suicide cluster ranged between 31 and 1626 days (Table 1). Cluster members were more likely to be aged 18 years or less (62.2%, 23/37) compared to non-cluster members (29.83%, 892/2990, $p < 0.01$). Evidence of prior exposure to suicide was reported among 64.9% (24/37) of cluster members compared to 6.09% (182/2990) of non-cluster members and this difference was statistically significant ($p < 0.001$). The remaining demographic characteristics were comparable among cluster and non-cluster members (online Supplementary Table S6).

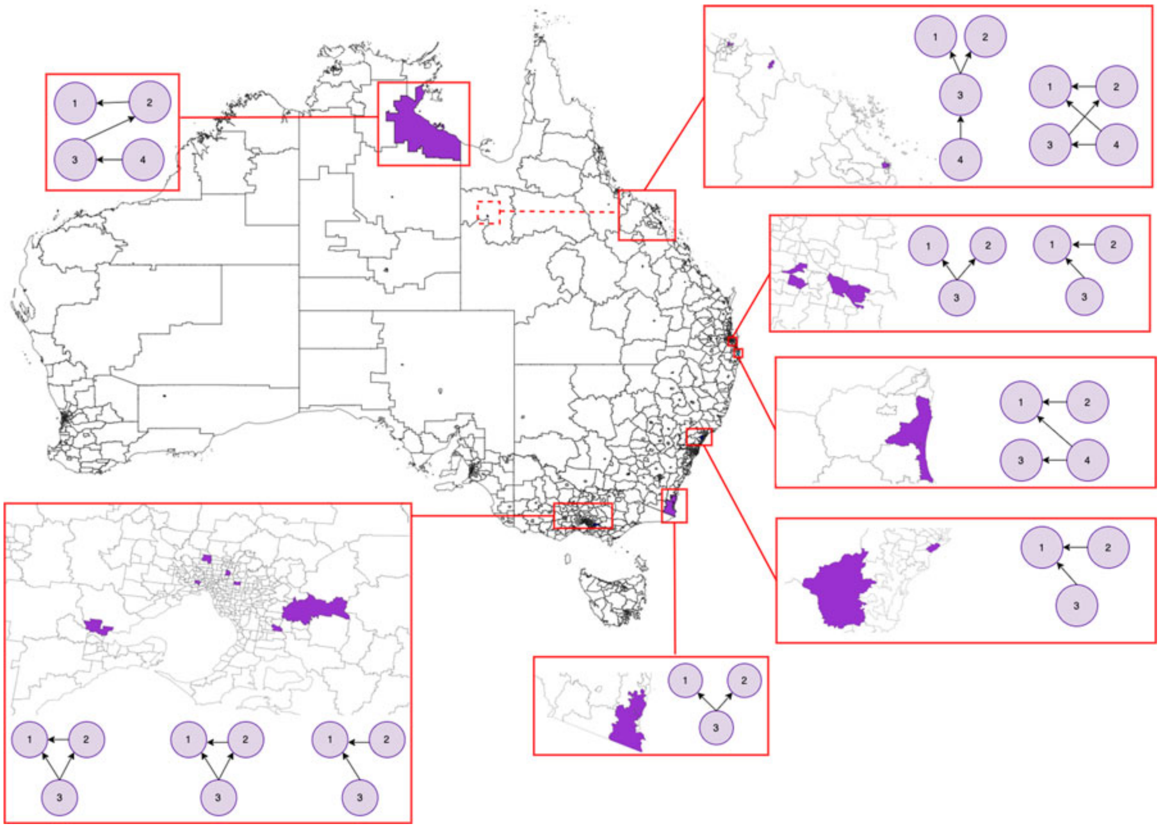

Fig. 3. Geographical locations of suicide clusters identified in Australian youth in 2006–2015 using descriptive network analysis of social linked suicide clusters. Geographic regions are based on Statistical Area 2 geographies (purple). The numbered nodes represent the sequence in which the suicide occurred beginning from the index death (1). The arrows represent the direction of exposure to suicide, and the connection between individuals in a suicide cluster.

Comparison of cluster detection methods

Overall, <50% of suicide clusters were identified by more than one cluster method (Table 1, Fig. 4a–c). The majority of overlapping clusters involved those that were detected from coronial inquests and the descriptive network analysis (four out of eight clusters). However, spatial congruence between overlapping clusters was low (<100% of SA2s). The duration of suicide clusters ranged between 6 and 725 days using the scan statistic, 121–914 days using information from coronial inquests, and 31–1626 days using descriptive network analysis. Overall, one-third (12/133) of cluster members were identified by more than one cluster detection method, however the number of young people that were identified by more than one method ranged from 1 to 3 individuals.

Discussion

This study identified suicide clusters in Australian youth aged 10–24 who died by suicide in 2006–2015. Comparative analysis of the three cluster detection methods showed considerable heterogeneity in the location, duration and size of suicide clusters, as well as both the number and demographic characteristics of cluster members. Together these findings demonstrate that the ways in which suicide clusters are defined and operationalised can result in markedly different suicide clusters. This was corroborated by our comparison of cluster members which showed that 90.8% of individuals who were involved in a single suicide cluster were not identified in overlapping clusters, using alternate cluster detection methods.

Although inferential approaches for the detection of suicide clusters have many empirical advantages (e.g. the facilitation of evidence based-decision making), the accuracy and precision of suicide clusters detected using the scan statistic depends on predetermined spatial and temporal parameters, for which there is currently no-gold standard. Results from both the coronial inquest into suicide clusters and the descriptive network analysis revealed that the maximum duration of suicide clusters ranged between 2.5 and 4.5 years, respectively. Together, these findings suggest that the predetermined 2-year parameter used in the scan statistic analyses did not correspond with the maximum duration of suicide clusters that were perceived as significant by local communities, nor suicide clusters which involved social links between cluster members. Since both the coronial inquest into suicide clusters and the descriptive network analyses were conducted on a nationwide scale and therefore overcome some of the limitations of earlier descriptive studies (e.g. small study effects and limited generalisability) results from the present study have the potential to better inform the parameters used in inferential studies of suicide clusters.

In the present study, six out of seven suicide clusters involved in coronial inquests verified by the coroner as being greater than statistically expected. Despite this, there was limited geospatial overlap between coronial inquests and suicide clusters that were identified using the scan statistic. It is likely, that these differences were influenced by broad area aggregation

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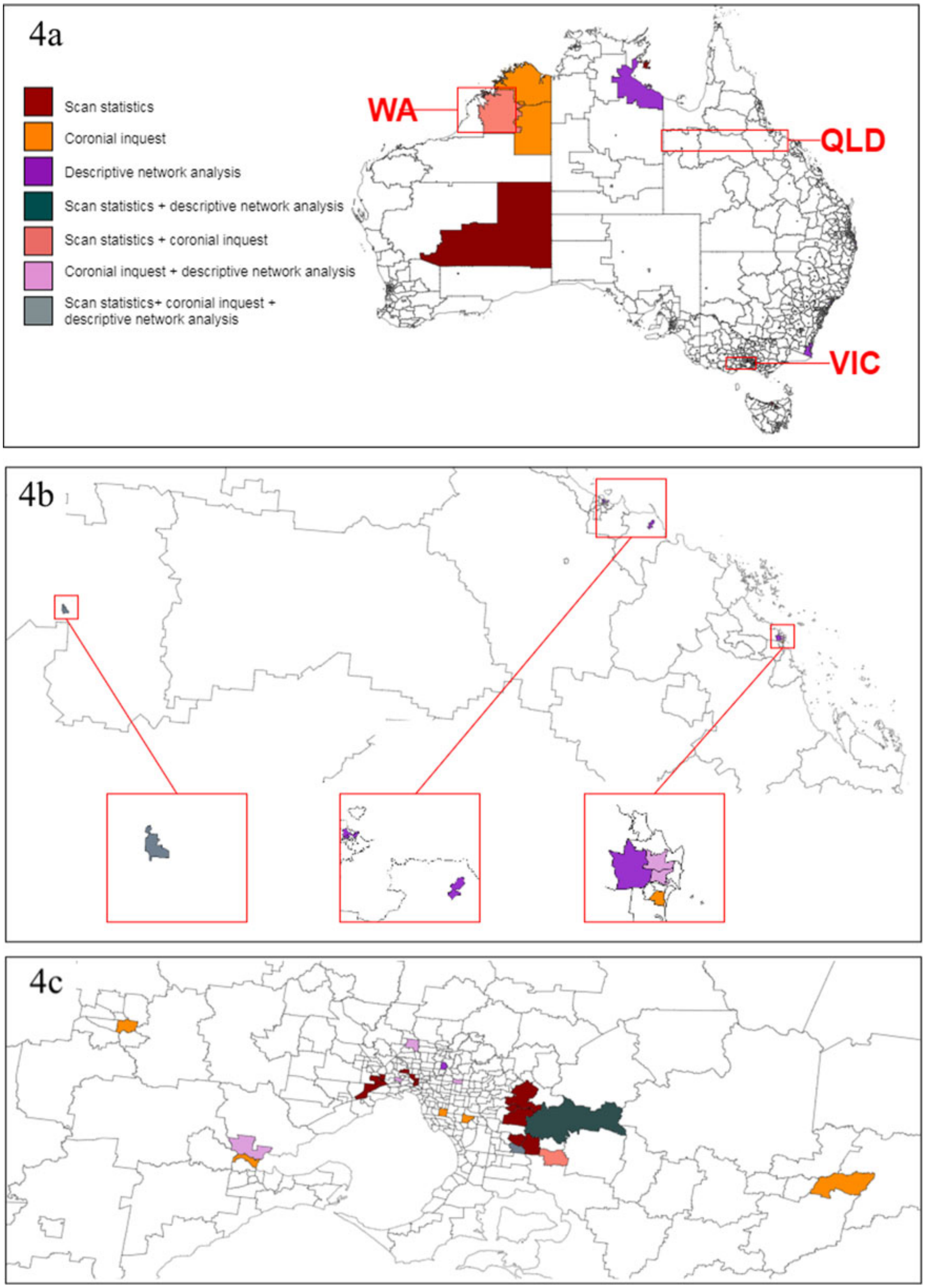

Fig. 4. (a) Overlapping clusters that occurred across Australia; (b) overlapping clusters that occurred in smaller regions across Queensland (QLD); (c) overlapping clusters that occurred smaller regions across Victoria (VIC). All suicide clusters that were detected using the scan statistic occurred within a 100km radius but are visualised using SA2 boundaries

and subsequent differences in the geospatial boundaries used for each method (Nelson and Brewer, 2017). Suicide clusters that were detected using the scan statistic, for example, were aggregated by SA2s, however suicide clusters that were detected using coronial inquests did not correspond with precise SA2 boundaries. These findings suggest that spatial parameters comprising broad area aggregations may have limited translational benefit for local communities and stakeholders that are tasked with responding to suicide clusters. The use of point-level geocoded data has been shown to effectively distinguish between the suicide profiles of small community settings and has the potential to overcome spatial biases that arise due to broad area aggregation in studies of suicide clusters (Torok *et al.*, 2019). Future research which investigates relevance of different spatial parameters among stakeholders who are responsible for the coordination of targeted suicide prevention and cluster response activities at the local and regional level is therefore warrented.

Exisiting guidelines for the detection response and prevention of suicide clusters recommend that community stakeholders use both inferential methods and descriptive methods to identify the links between cluster members. Although the descriptive network analyses were conducted using nation-wide data, information on prior exposure to suicide was not consistently recorded in the NCIS, resulting in linkage among only 60% of exposed cases. Routine collection of exposure to suicide as part of the police and coroner investigation as well as the inclusion of exposure to suicide in the core-data set of suicide cluster surveillence systems has the potential to improve the sensitivity and specificity of suicide clusters that are characterised by social links between cluster members.

Lastly, results from the present study provide some insight into the mechanisms underlying suicide clusters. Lifetime prevalence of exposure to suicide among cluster members that were detected using the scan statistic was 10.1% compared to over one third of cluster members involved in 32.5% of clusters identified through coronial inquests, and 52.6% of cluster members identified using descriptive network analyses. These findings are contrary to previous studies that suggest that the close spatial and temporal parameters used in the scan statistic is consistent with a social transmission hypothesis (Gould *et al.*, 1990*a*; Robinson *et al.*, 2016; Helbich *et al.*, 2017; Sy *et al.*, 2019). Whilst the prevention of the social transmission of suicidal behaviour is a core component of existing cluster response guidelines in Australia (Centre for Health Policy Programs and Economics, 2012) and internationally (Centers for Disease Control, 1988; Health Service Executive (HSE), 2011; Public Health England, 2015; Palmer *et al.*, 2018; Public Health England, 2019), results from the present study suggest that not all clusters involve social links between cluster members.

Limitations

Although the NCIS is a comprehensive database on coroner determined causes of death, information included in the NCIS is retrospective and may not be immediately available to communities that are experiencing a suicidal crisis. Furthermore, data included in our analysis was dependent on the narrative text of police and coroner's reports. Consequently, information on prior exposure to suicide may not have been recorded if it was not included in the police or coroner investigation, or if informants involved in the investigation did not have knowledge of the young person's exposure to suicide. Lastly, the limited geospatial congruence between suicide clusters that were detected using the scan statistic are an artefact of the spatial and temporal parameters used in the analysis (Cheung *et al.*, 2013; Nelson and Brewer, 2017), specifically aggregation of suicides using SA2s. Future research should therefore seek to acquire point data in order to detect suicide clusters using inferential methods with greater accuracy and precision.

Conclusions

The present study showed that the same data – when analysed in different ways – may lead to the detection of different suicide clusters. Whilst some suicide clusters involved social links between suicide descendants, not all cluster members had a history of prior exposure to suicide. The collection of exposure to suicide as part of routine police and coroner investigations has the potential to improve the ways communities respond to suicide clusters by distinguishing between suicide clusters that may or may not be driven by social links between cluster members. Finally, results from the present study have the potential to inform the parameters used in inferential studies of suicide clusters, particularly among local suicide prevention teams that are tasked with responding to suicide clusters.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S2045796020000645.

Data. The NCIS, the database used in the current study, has no public access due to the sensitivity of the suicide data.

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Conflict of interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. This study received full ethical approvals from the Justice Department Human Research Ethics Committee (CF/15/13188).

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