Railway suicide clusters: how common are they and what predicts them?

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ABSTRACT

Background A growing number of studies have sought to detect clusters of all suicides, but few have sought to identify clusters of method-specific suicides.
Methods Data on railway suicides occurring in Victoria, Australia, between 2001 and 2012 were obtained from the National Coronial Information System. We used the Poisson discrete scan statistic to identify railway suicides that occurred close together in space and/or time. We then used a case–control design to compare clustered railway suicides with non-clustered railway suicides on a range of individual and neighbourhood factors.
Results We detected four spatial clusters that accounted for 35% of all railway suicides. Railway suicides by individuals who were hospitalised for mental illness had nearly double the odds of being in a cluster compared with those individuals who had never been hospitalised (OR 1.80, 95% CI 1.02 to 3.18). Higher frequency train services were associated with increased odds of being in a cluster (OR 1.11, 95% CI 1.03 to 1.19). No other predictors were associated with being in a cluster.
Conclusions Railway suicides that occur in clusters warrant particular attention because of the ripple effect they can have for communities and the risk that they may lead to copycat acts. Railway suicide prevention strategies should consider the fact that these suicides can occur in clusters, particularly among individuals who had previous hospitalisations for mental illness or live in areas with high-frequency train services.

INTRODUCTION

Suicide clusters are generally defined as an unusually high numbers of suicidal behaviours occurring close together in space and/or time than would be typically expected.[1] Their actual or perceived presence causes considerable community concern. Three types of suicide clusters have been identified in the literature.[2 3] The first of these is mass clusters or temporal clusters, which occur comparatively close in time across varied locations. The second is spatial clusters, which take place within a small geographical area, not bounded by time. The third type, known as point clusters or spatial–temporal clusters, involves suicides occurring in close temporal and geographical proximity to each other. Identifying and monitoring suicide clusters is important because this can facilitate intervention efforts to prevent further suicides.

Previous research has focused on detecting clusters of all suicides, paying little attention to the way in which people took their own lives. Few studies have sought to identify method-specific clusters.[1 4] A small amount of work has detected clusters of railway suicides and some of them have found that these clusters tended to be located close to psychiatric institutions.[5–11] However, these studies are limited because they relied on 'rule-of-thumb' definitions of a cluster (eg, three or more railway suicides occurring in particular location[5] or at least two railway suicides recorded in a 2 km section of railway track)[10 11] rather than using a definition that is conditional on the underlying railway suicide rate in the population and therefore adjusting for unevenness in the population distribution.

This study employed the scan statistic from the SaTScan[12] to examine whether there were clusters of railway suicides. In general, this technique considers the population size and the rate of the public health problem of interest. It has been commonly used to detect clusters of communicable diseases and is increasingly being used to detect overall (as opposed to method-specific) suicide clusters.[1 13–15] Our aims were to (1) identify clusters of railway suicide and (2) having done this, use a case–control design to investigate individual and neighbourhood factors that might be associated with a railway suicide being part of a cluster. This study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement for reporting case–control studies.[16]

METHODS

Setting

Victoria is the second largest state in Australia with a population of approximately 5.7 million people. The vast majority of people live in Melbourne, the state's capital (population 4.1 million), which is serviced by a metropolitan railway network consisting of 16 railway lines with 230 railway stations. Among those who travel to work by public transport, 70% of commuters use train services.[17] The average distance between the metropolitan stations is 2 km.[17] Approximately 90% of the railway network is unfenced. The railway tracks are generally constructed at ground level and contain a large number of level crossings.

Railway suicide deaths

Data on deaths classified as intentional self-harm by railway vehicle (ICD-10 code X81) in Victoria between 2001 and 2012 were obtained from the National Coronial Information System (NCIS). The NCIS is a national Internet-based data storage and retrieval system of Australian coronial records. It provides access to the full-text reports generated from each investigation: the police summary of circumstances, the autopsy report, the toxicology report and the coroner's findings. It also provides coded information on sociodemographic characteristics of the deceased, including age, sex, marital status and employment status. To avoid missing potentially relevant cases, we cross-referenced all cases we identified in NCIS with all railway suicides deaths identified by the Coroners Court of Victoria.

We selected 2001–2012 time period because NCIS contained the most complete data for these years. We excluded cases which were still under investigation on the date of data extraction (11 August 2015) (n=21). We also excluded cases that had missing information on usual residential postcode (n=6) or where the deceased's home was located outside Victoria (n=2).

Variables of interest

A range of individual and neighbourhood variables were used to examine the odds of a railway suicide being in a cluster. Individual measures included sex, age, marital status, employment status, diagnosed mental illness and mental health hospitalisation history. The following neighbourhood variables were included in the analysis: social fragmentation, socioeconomic status, train-related variables (eg, train frequency, patronage volume), number of assaults, concentration of alcohol outlets, number of mental health services, number of secondary schools and overall suicide rate. These variables were all measured at the postcode level and merged with the residential postcodes of railway suicide cases. All these individual and neighbourhood variables are described in online supplementary file in terms of their year(s) of availability, their operational definition and their source.

Statistical analysis

To detect clusters of railway suicides, we used the postcode representing the residential location of the deceased as the spatial unit of analysis. We performed Poisson discrete scan statistic using SaTScan V.9.4.1 to investigate the presence of three types of clusters: temporal, spatial and spatial–temporal clusters.(Kulldorff M. SatScan: Software for the spatial, temporal, and space-time scan statistics. 2015. http://www.satscan.org/. Accessed 5 October 2015) SaTScan requires information on cases, population estimates and area coordinates in a particular format to run the analysis. Therefore, we aggregated the number of railway suicides by month of the death and residential postcode. We obtained population estimates for each postcode from the Australian Bureau of Statistics (ABS) 2006 census data (the study midpoint). We used ArcGIS to compute the geographical coordinates of the postcode centroids based on the 2006 ABS digital map at postcode level.

After importing the required data into SaTScan, we prespecified the size of the spatial and temporal scan windows. To set the spatial window, we first calculated the incidence rates of railway suicides for each postcode and obtained a maximum rate of 0.0417 per 100 persons. A previous study comparing multiple scans with different spatial parameters found that a small value for the spatial window is advantageous for detecting smaller clusters, and this is potentially useful for the development of prevention initiatives.[18] For this reason, we set the size of any railway suicide cluster to not larger than an area with 4.17% of the total population at risk. We chose circular as the shape of the spatial scan window because this shape has been commonly used to detect clusters.[19] Our temporal window was set from a minimum of 1 month to a maximum of 12 months. This interval was based on the advice from a recent systematic review on suicide clusters.[20] Used in combination, these settings meant that a set of cylinders was used to scan regions in the spatial–temporal analysis, with the circular base representing the area of the potential cluster and its height corresponding to the potential cluster's time.

The likelihood of each potential cluster was assessed using Monte Carlo stimulation.[12] Clusters were considered to be statistically significant if their p value was <0.05. Railway suicides detected in the significant clusters were therefore categorised as clustered suicides, and railway suicides located outside these clusters were categorised as non-clustered suicides. We then used logistic regression to examine the effects of study variables on the odds of a railway suicide being in a cluster. Cluster-adjusted robust SEs (based on postcode) were used to account for a possible within-postcode correlation in the outcome. Univariate analyses were performed for all exposure variables. Following this, variables which were significant in the univariate analyses were tested in a multivariate model, controlling for individual age and sex and known confounders (eg, socioeconomic status[21]). Because some of our train-related exposure variables had values of either zero (representing no exposure) or a positive number (representing, eg, number of train stations), we coded these variables using the procedure recommended by Robertson and his colleagues.[22] This meant that these variables had two terms entered into the model: an indicator variable for when the variable had a value of zero and a linear term for when the variable had a value greater than zero.

Sensitivity analysis

We undertook a sensitivity analysis to re-estimate the location and size of any clusters using the location of the suicide instead of the residential location of the deceased (in 55% of cases this was the same postcode). To do this, we used the postcode where the death occurred as the spatial unit of analysis, with all other parameters remaining the same as that used for our primary analysis.

Ethical approval

This study was approved by the Health Sciences Human Ethics Committee (the University of Melbourne) and the Justice Human Research Ethics Committee (State Government Victoria). The study has conformed to the principles embodied in the Declaration of Helsinki.

RESULTS

Detection of clusters

Using residential location as the spatial unit of analysis, we identified four spatial clusters in which the observed number of railway suicides significantly exceeded the underlying rate of railway suicides. Within these clusters, there were 120 railway suicides, representing 35% of all railway suicides (120/347) occurring during the study period. The clusters ranged in size from 23 to 38 suicides. The minimum radius of the cluster area was 4.0 km and the maximum was 9.5 km (see table 1). All clusters were located within urban areas. They contained sections of 7 out of 16 urban train lines, with 2 train lines involved in two separate clusters. The majority of cluster-related railway suicides (66%) occurred on open tracks (ie, anywhere between a station and a road/pedestrian level crossing, where train tracks and roads/pedestrian paths intersect) and the remainder were within station areas (16%), at level crossings (9%) and at pedestrian crossings (9%). Five mental health institutions that provided inpatient treatments were located within the areas that bounded these clusters, while several others surrounded them. We identified no temporal or spatial–temporal clusters.

Table 1 Information of spatial clusters of railway suicides in Victoria, Australia

Residential location-based clusters				Suicide location-based clusters			
Cluster	No. of cases	Radius (km)	p Value	Cluster	No. of cases	Radius (km)	p Value
1	38	9.54	<0.001	1	32	6.40	<0.001
2	23	5.07	0.02	2	17	3.35	<0.001
3	30	4.84	0.03	3	18	2.49	0.027
4	29	4.04	0.04	–	–	–	–

Factors associated with railway suicides occurring in clusters

The findings from the univariate analyses (table 2) showed that having a diagnosed mental illness, being hospitalised for mental illness, living in an area with a high proportion of train commuters and living in an area with a high-frequency train services were associated with elevated odds of a railway suicide being in a cluster.

These variables were then assessed in a multivariate model (table 3). Because mental illness was associated with mental health hospitalisation history (Fisher's exact test, $p<0.001$), we only included the latter variable on the grounds that it is a better measure of acute mental health problems. Socioeconomic status is often associated with station density so we also included this as a potential confounder variable.[21] As a result, we found that mental health hospitalisation history and train frequency remained as strong predictors of a railway suicide being in a cluster in the multivariate model. Increased odds of being in a railway suicide cluster were found among those with a past hospitalisation history (OR 1.80, 95% CI 1.02 to 3.18), but not for those currently being treated as an inpatient (OR 0.46, 95% CI 0.15 to 1.41). Living in an area with high-frequency train services was also associated with being in a railway suicide cluster (OR 1.11, 95% CI 1.03 to 1.19).

Findings from the sensitivity analysis

When using suicide location as the spatial unit of analysis, we identified three spatial clusters and no temporal and spatial–temporal clusters (table 1). There were 67 railway suicides, representing 19% of all railway suicides included in our study. The clusters' size ranged from 17 to 32 suicides. The minimum radius of the cluster area was 2.5 km and the maximum was 6.4 km. These clusters were smaller in size compared with the clusters based on residential location. Two of the clusters were located within clusters 1 and 4 (residential location-based) separately, while the other cluster overlapped with cluster 3 (residential location-based).

DISCUSSION

We identified four spatial clusters of railway suicides when using residential location as the unit of analysis and three spatial clusters when using suicide location. We found no temporal or spatial–temporal clusters when using either location. Our use of residential location as the spatial unit of analysis is important because the location where people live may have a strong influence on their mental well-being[23,24] and consequently, their risk of suicide. This may be particularly important from the point of view of preventing the suicide contagion (ie, the process whereby one suicidal act in a community triggers several other suicidal acts) because of the amount of time people spend in their neighbourhood. The use of suicide location as another spatial unit of analysis is also noteworthy because contagion can occur if people witness a suicide or know a location is a suicide hotspot.[25,26] Contagion is one of the most frequently used explanations for the formation of suicide clusters.[3,27,28]

We found that two suicide location-based clusters were completely contained within the same areas as two larger residential location-based clusters. We also found that another suicide location-based cluster overlapped with a residential location-based cluster. These findings are consistent with previous research that many railway suicide victims chose a suicide location that was in close proximity to their home.[29–31] Based on this, we suggests that community-based interventions for cluster-related communities could be implemented within the residential location-based clusters while interventions related to the amendments of railway environments could be carried out within the suicide location-based clusters.

The Australian government has developed a community plan for preventing and responding to suicide clusters.[32] This plan contains postvention strategies that should commence as soon as a potential cluster is perceived or when a cluster is forming. Postvention could be undertaken in the residential location-based clusters. Some examples of proposed postvention activities are providing immediate support to the bereaved, providing information about available support services and promoting access to debriefing and counselling for affected people.

Suicide location-based clusters can be thought of as similar to suicide hotspots in the sense that both are bounded by geographically defined suicide locations, except clusters are often based on a wider area and hotspots are usually identified at public, often iconic, sites. A considerable amount of work has been done on preventing suicide at suicide hotspots, and three interventions show particular promise (ie, restricting access to means, encouraging help seeking and increasing the likelihood of intervention by a third party).[33,34] Restricting access to mean has been shown to be successful in places such as the stations in Hong Kong, Japan and South Korea,[35–38] but may be difficult in places where the majority of cluster-related railway suicides occur on open tracks (as shown in our study). However, there may still be opportunities for reducing access to these parts of the track at cluster areas using physical barriers such as fencing or removing level crossings. This has the potential to buy time to allow suicidal individuals reconsider their actions and enable others to intervene. This has also the potential to reduce non-intentional injuries on the track. Increasing surveillance such as installing video cameras along the track at cluster locations may also be useful.

Our work shows that people who had a history of mental health hospitalisation prior to death are particularly vulnerable to railway suicide within a cluster, and this may have implications for the way in which we target some of the abovementioned interventions. For example, particular vigilance might be required at cluster sites that are located near mental health facilities and these sites should be given priority in investing in restricting access to means. Railway personnel, staff from mental health facilities and other relevant stakeholders might want to work together to address railway suicides.

Our work also found that a high frequency of train services is an important neighbourhood risk factor. This makes sense; we know that there is a greater opportunity for railway suicides if there are more trains passing through a particular portion of track. It also provides indicators as to where relevant stakeholders might best focus prevention efforts. For example, stakeholders might want to emphasise increasing the likelihood of

Table 2 Descriptive results and ORs from univariate logistic regression analyses

Variable	Clustered cases (N=120), n (%)/mean	Non-clustered cases (N=227), n (%)/mean	Unadjusted OR	95% CI	p Value
Individual level					
Sex					0.92
Male*	84 (70.0)	160 (70.5)	1.00		
Female	36 (30.0)	67 (29.5)	1.02	0.65 to 1.61	
Age					0.83
≤34	55 (45.8)	109 (48.0)	0.81	0.40 to 1.64	
35–39	45 (37.5)	86 (37.9)	0.84	0.43 to 1.62	
≥60*	20 (16.7)	32 (14.1)	1.00		
Marital status†					0.14
Married (including de facto)*	30 (41.7)	67 (41.9)	1.00		
Never married	26 (36.1)	73 (45.6)	0.80	0.44 to 1.43	
Widowed	3 (4.2)	2 (1.3)	3.35	0.57 to 19.8	
Divorced	2 (2.8)	8 (5.0)	0.56	0.12 to 2.70	
Separated	11 (15.3)	10 (6.3)	2.46	0.95 to 6.38	
Employment status†					0.39
Employed*	38 (41.8)	72 (38.9)	1.00		
Unemployed	21 (23.1)	34 (18.4)	1.17	0.63 to 2.17	
Not in the labour force	32 (35.2)	79 (42.7)	0.77	0.46 to 1.29	
Mental illness†					0.03
At least one diagnosis	83 (82.2)	133 (72.7)	1.73	1.04 to 2.88	
No diagnosis*	18 (17.8)	50 (27.3)	1.00		
Mental health hospitalisation†					0.02
Current inpatient	6 (6.8)	25 (14.1)	0.57	0.20 to 1.63	
Past inpatient	40 (45.5)	53 (29.9)	1.78	1.07 to 2.96	
Never inpatient*	42 (47.7)	99 (55.9)	1.00		
Neighbourhood level					
Social fragmentation	1.8	1.4	1.04	0.93 to 1.17	0.48
Socioeconomic status					
Index of relative socioeconomic Disadvantage	6.1	6.0	1.01	0.88 to 1.17	0.86
Index of Economic Resources	5.9	6.1	0.98	0.85 to 1.13	0.80
Train-related factors					
Availability of trains					
Presence of railway tracks					0.45
Yes	106 (88.3)	189 (83.3)	1.52	0.52 to 4.47	
No*	14 (11.7)	38 (16.7)	1.00		
Train frequency	15.3	8.7	1.11	1.04 to 1.19	0.001
Train speed	72.1	61.7	1.01	0.99 to 1.02	0.12
Accessibility to trains					
No. of surveillance units†	2.1	1.9	1.00	0.92 to 1.10	0.95
No. of level crossings	6.2	3.0	1.21	0.98 to 1.50	0.08
No. of stations	2.0	1.4	1.56	0.99 to 2.45	0.06
Familiarity with trains					
People travel to work by train	15.5	11.5	1.05	1.01 to 1.10	0.02
No. of station patronage†	2.2	2.0	1.00	0.88 to 1.14	0.99
No. of pedestrian	5.8	3.9	1.06	0.96 to 1.17	0.23
Other contextual variables					
No. of assaults	1.9	1.5	1.12	0.83 to 1.47	0.48
Alcohol outlets density	3.3	3.7	0.99	0.94 to 1.04	0.67
No. of mental health services	2.1	1.8	1.04	0.86 to 1.25	0.67
No. of secondary schools	2.5	2.6	0.95	0.69 to 1.29	0.73
Overall suicide rate	16.4	20.0	0.99	0.98 to 1.01	0.28

*Reference category.
†Employment status was missing for 20.5%, marital status for 33.1%, mental health inpatient status for 23.6%, mental illness for 18.2%, number of schools for 11.8%, number of station patronage for 11.2% and number of surveillance units for 8.4% of the total railway suicide cases. They were excluded from the analyses.

intervention by a third party at these sites. To do so, they might make particular efforts to train railway personnel and security staff in how to intervene with someone who they think might be at risk.

Finally, we found that railway suicides did not cluster in time and space–time. One explanation is that this may be due to the introduction of media guidelines in 2002,[39] which limited the public's exposure to information about suicide. In support of

Table 3 ORs from multivariate logistic regression analysis

Variable	Adjusted OR†	95% CI	p Value
Individual level			
Mental health hospitalisation			0.02
Current inpatient	0.46	0.15 to 1.41	
Past inpatient	1.80	1.02 to 3.18	
Never inpatient*	1.00		
Neighbourhood level			
Train frequency	1.11	1.03 to 1.19	0.01
People travel to work by train	1.02	0.97 to 1.07	0.48

*Reference category.
†Adjusted for the variables in the table as well as age and sex and socioeconomic status of the postcode.

this, an Australian study that evaluated changes in media reporting of suicide between 2000/2001 (before the guidelines were introduced) and 2006/2007 (after their introduction) found that <11% of media items included details of specific suicide methods in either time period.[40]

Strengths and limitations

This study provides the first important piece of evidence on clusters of railway suicides using a rigorous statistical approach. It systematically explored clusters close in time and/or space. It considered both individual and neighbourhood factors associated with the odds of a railway suicide occurring in a cluster. We used a specific spatial parameter size based on the maximum incidence rate rather than using the default value (50%) usually used in the previous studies.[15 41] This seems to provide a more precise detection of clusters (cross-checked by visualising local railway suicide rates). We also employed a smaller percentage of population at risk to allow identification of smaller sized clusters in larger numbers.

This study also has some limitations. First, the number of railway suicides may be underestimated as active coronial investigations could not be included in the analysis. Second, some information was missing on several individual variables and on two neighbourhood variables. However, this is unlikely to have influenced the findings on factors related to clustered risk because the proportions of missing data in cases and controls were fairly similar. Third, the use of a circular shape means that we have missed clusters that can be characterised by other shapes; for instance, an ellipse and irregular shapes. Fourth, we did not have data on direct exposure to suicide (whether the deceased knows someone else died by railway suicide). Instead, we relied on proxy measures such as individual hospitalisation history and area suicide rate to assess clustered odds. Fifth, our methodology only allows for detecting clusters in close spatial and temporal proximity but does not allow examining other types of clusters; for example, clusters occurring in close social and familial proximities. Sixth, we used area centroids instead of population weighted centroids (determined by population distribution over the space of a postcode area) because we were not able to compute population weighted centroids for all postcodes from the smallest geographical unit (collection districts) as they do not correspond well to postcodes. This is likely to have influenced the results in regional and remote areas where postcodes are typically large. Most of our data, however, come from a major city, where the postcodes are smaller. Finally, most of the railway suicides in this study come from a major city; findings may not be generalisable to areas where most railway suicides occurring in rural locations.

CONCLUSIONS

Although railway suicides are traumatic, railway suicides that occur in spatial clusters present a particular problem because of their cumulative impact on train drivers, other railway staff, passengers and bystanders. They may also become self-perpetuating and confer a risk of copycat acts. This work confirms that railway suicides are a phenomenon that must be acted on and offers some clues as to where prevention efforts should be focused.

What is already known on the subject?

- Railway suicide is relatively rare but highly lethal.
- Several previous studies have used ‘rule-of-thumb’ methods to identify locations where railway suicides cluster together.

What this study adds?

- Methods used for identifying clusters of disease can also be used to identify clusters of railway suicides.
- We identified four clusters that accounted for approximately one-third of all railway suicides.
- Railway suicides by people with a history of hospitalisations for mental illness or by people living in areas with high-frequency train services are particularly likely to occur in a cluster.

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Contributors MJS, JP and LST participated in the design of the study. LST was involved in data collection with support from LB. LST performed the statistical analyses with help from MJS and AM. All authors interpreted the findings. LST took the lead on writing the manuscript, and all authors commented on earlier drafts and approved the final manuscript.

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Maori injury disability worse

A University of Otago study published in the *Australian and New Zealand Journal of Public Health* shows injured Maori face higher rates of long-term disability. As well as social factors such as poverty, the study also suggests that injured Maori have difficulties 'accessing health services' that could contribute to disability.

Drug impaired woman jailed after hitting cyclist

An Australian woman who had been taking 'ice' (the most potent form of methamphetamine) drove on the wrong side of the road and hit a cyclist leaving him with devastating injuries. The woman did not stop to help the victim. She fled to a friend's home where she hid the car, explaining that she had hit a kangaroo. She was sentenced to 6 years in jail.