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WHAT DO WE KNOW ABOUT RAIL SUICIDE INCIDENTS?
ANALYSIS OF 257 FATALITIES ON THE RAIL NETWORK IN GREAT BRITAIN
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Abstract –
There are over two hundred and fifty suicides on the railway in Great Britain (GB) each year. Descriptive statistics are compiled, producing national and international data. The industry know how many and, to a limited extent, where these fatalities occur. There is little in-depth analysis of events. Therefore, there are gaps in knowledge of these fatalities and this is a weakness when considering the best approaches to prevention. This paper reports on the analysis of data on 257 suicide events at or near to 51 stations on three rail routes in Great Britain over a 20 year period. The analysis uses data from the industry Safety Management System (SMIS) database and produces simple descriptive statistics on a range of variables, including comparisons across the three rail routes. Additional data from staff and route based documentation have been used to verify, supplement and interpret information in the database. Examples of patterns of immediate and precursor behaviours during incidents have been presented, illustrating the potential to explore both common and anomalous behaviours during events. The findings demonstrate the type of content that can be explored within the industry data and through use of other data that are available within the industry. Commentary is provided on the strengths and weaknesses of the data and how findings from the analysis can be used to improve future data collection and prevention of incidents.

Keywords – Rail suicide, Rail Safety, Risk factors, Accident Analysis, Security, Stations, Incident data

Introduction

There are over two hundred and fifty fatalities due to suicide each year on the GB rail network [1]. This is a problem that is shared with many other countries (e.g. in Europe and worldwide), with distress to train crew and the public, damage to trains and infrastructure and significant impacts on rail network performance, in addition to the consequences for the person attempting suicide. Predicting the locations of future events, identifying those at risk and understanding the effectiveness of solutions to railway suicide are difficult challenges for the industry and researchers who are working on this topic.

From a practical point of view, information on rail suicide events is collected by a number of different stakeholders. For example, the British Transport Police collect evidence to determine whether there are any suspicious circumstances (e.g. a crime rather than a suicide) and their findings are used subsequently by the coroner in inquests to determine the cause of death. Other details of events are collected by first responders to events in the industry (e.g. Network Rail staff). Witness statements can be collected from drivers or people who might have seen the event at platforms or railway crossings. Evidence on what happened may be available from CCTV cameras at stations. However, information from these different sources is not generally shared across organisations or easily accessible.

Details of the incidents are compiled, classified and recorded in various sources, such as organisational databases (e.g. the industry Safety Management Information System (SMIS) database - http://www.rssb.co.uk/risk-analysis-and-safety-reporting/reporting-systems/smis) and other industry records which contain details of the times, locations and circumstances of events. These sources contribute to summary statistics, such as those provided in the RSSB Annual Safety Performance Report [1] or European wide statistics [2], covering fatalities and injuries arising from work, travel or other interactions

with the rail network. These data give an overall understanding of the national and international distributions of events (e.g. details of numbers of suicides, indications of locations, demographic details and national trends, in conjunction with other rail safety data). Similar analyses can be found in a variety of academic publications, for example containing comparisons of the numbers of train suicides from statistics from different country, the ratio of male to female suicides, train suicide as a proportion of all suicides and the fatality rate for rail suicide attempts [3]. Many studies have sought to investigate the types of factors that can influence incidents, attempting to draw conclusions on the impacts of individual (age, gender, health / mental health), situational (location, time of day, frequency of trains, type of train, crowding at stations), environmental (weather and lighting conditions) and socioeconomic factors (indicators of deprivation) on these types of incidents. Table 1 shows a wide range of factors that have been considered in a selection of reviews (e.g. [3], [4]) and other studies.

[Table 1 about here]

There has clearly been an extensive set of investigations of a wide range of factors (Table 1). There are some areas of consistency in the findings (e.g. slight dominance of male suicides on the railway [10], [11]) and much variation (e.g. in the numbers of seasonal, monthly or weekly fatalities or patterns in the time of day [26-31]). There are a few areas with differences (e.g. the influence or lack of influence of railway parameters such as train frequency or population density [9], [37]; or different opinions on the impulsive or pre-planned nature of these events [13], [14]). Some of the differences might be explained by national differences (cultural or structural factors such as the density of the railway [37]) or because phenomena are measured in a different way across studies. Some important explanatory details (e.g. from Table 1) are not collected routinely and even if they are, they are not classified and used effectively in prevention. For example, no studies so far have collected detailed data on the specific line on which incidents occur, precisely where they occur and how people get access to these points of the railway. There is also limited

published evidence on details of behaviour of people prior to incidents. References to pre-suicidal behaviours have so far focused on actions or behaviour which might arouse suspicion in observers, such as dropping possessions, erratic gestures and wearing unusual clothing [15], [20], [22], [23]. Efforts have also been made to classify how people make contact with the train ("jumping", "lying", "wandering") [24], 25]. However, descriptive details of these behaviours are limited and focus on behaviours that are often too late in time to help with prevention.

In this study, information in the SMIS database has been reviewed and used to learn more about incidents that have occurred at a sample of stations over an extensive period of time. This database is compiled and updated by rail organisations (e.g. RSSB, Network Rail), collecting data on a wide variety of accidents and incidents in the rail industry. In relation to rail suicide, the database contains basic descriptions of the time, location and circumstances of the events and incorporates updates over time as new information emerges. This could include extracts from driver statements, relevant details from the British Transport Police logs and results from Coroners' inquests. This database is therefore a potential source of a broad range of information on these incidents. Findings are presented from the analysis of fatalities that have occurred at or near to stations in three areas close to London over a 20 year period. It therefore aims to determine the type of information that can be identified from industry databases and other documentation about the incidents, including the locations of incidents, the potential to identify any patterns or trends in incidents and details of other factors that could influence the occurrence of the events. The findings from this analysis are used to explain what can be understood about fatality events on the rail network and how this knowledge can be used in improving approaches to prevention.

Method

General overview of the study

The study collates and analyses content from an industry database to develop a broader understanding of what is known about fatalities across a sample of stations and connecting track areas, over an extended time period. The analysis also intended to explore whether more learning could occur by looking in greater detail at some of the narrative content in the organisational records, in addition to other more commonly used content on circumstances surrounding these events (e.g. demographics, general descriptions of locations and train types).

Data sources

The primary source of data for this study is the SMIS (Safety Management Information System) database. Data from SMIS have been transferred to an Excel spreadsheet and supplemented where necessary with additional data and interpretation from staff in the industry. This includes records such as Event Review Forms (completed after a fatality by Network Rail staff to collect details of the location, prevention measures in place and issues needing rectification) and information from Network Rail's Performance Review Reports (reporting on a selection of events causing major disruption to traffic on the network, though with an emphasis on mitigation of consequences of the events rather than prevention). Relevant information from these sources, where available for a limited sun-set of incidents, was summarised in a single text field in the spreadsheet.

The original data set that was used contained details of all fatalities (suicide and accidental, N=344 over a 20 year period at the locations that have been selected for this study). Two hundred and fifty seven of these incidents have been classified as suicides or narrative verdicts in the database and these have been included within the current study. .

Study locations

To enable focus in greater depth on the suicide incidents, analyses have been carried out on three lengths of railway routes, situated close to London. The standard railway configuration on mainline railway in Great Britain is typically four track railway, with two fast lines (higher line speeds and infrequent stops at stations) and two slower lines (slower line speeds and where trains stop at most stations), though there is some variation in parts of the rail routes (e.g. two track railway or areas with additional electric lines). The railway is secured by fencing throughout the network and the easiest places of access tend to be at station platforms and railway crossings. There are occasions where people climb fencing or get access to the railway from road bridges over the railway. As such, historically, there have been greater numbers of fatalities at platforms and crossings, though it is also fairly common for people to move to other parts of the railway after getting access to the railway at these locations.

The stations in these three areas represent a range of characteristics, such as large mainline station locations serving densely populated areas and smaller stations in a mixture of urban and rural locations, with differing station configurations, track layouts, train services and stopping patterns. There are no rail crossings currently on these sections of mainline track. Descriptions of the three study areas are provided in Table 2.

[Table 2 about here]

Many of the stations have similar layouts, though there is clearly some variation in the stations. Figure 1a shows a typical station layout, illustrating the locations of platforms (shaded blocks) adjacent to the rail lines. These lines can be defined as faster lines (up main and down main) or slower lines (up relief and down relief); though there are some different naming conventions between the different study areas. At some stations, where trains do not stop, there are no platforms facing the fast lines, or these platforms are not accessible to passengers. Therefore, there is often no direct access to these faster lines. Figure 1b

shows an example of one of the stations with no facing platform to the fast lines, though it is possible for people to cross from slower line platforms to get access to the fast lines.

[Figures 1a and 1b about here]

Procedure for data collation and analysis

A preliminary meeting was held with RSSB staff to discuss requirements for the analysis. A data set containing selected fields from the national SMIS database (i.e. fields which could supply content on the factors in Table 1) was received in an Excel format from analysts at RSSB. Incidents, both at and between stations in the three areas were identified using text searches. Details from SMIS were cross-checked for accuracy with information from other documents that were held by staff who have responsibility for fatality prevention in each of the three routes.

Preliminary analysis of the content of the data sources was started using data from one of the three areas. Categorical, numerical fields and text descriptions were read and verified. Relevant data types were identified and a set of categories was established to record relevant information for each incident. The categories are listed in Table 3, along with details of the source and method of coding. Data relating to these categories were extracted and summarised in a new spreadsheet. Categories were revised and refined on this first pass through the data, returning to re-classify earlier content where necessary, to ensure consistency in collation and classification of the data. The process of collating and classifying content from the data sources was then applied to incidents in the second and third areas. The data types and categories were reviewed and refined at each stage of the analysis. Several variables from Table 1 have not been considered in this study. Socioeconomic data on these factors are not readily available and even where they are, at a regional level, are not easy to link to rail locations. Fatality rate was also not explored as all

events in this study were fatalities. There is low confidence currently in the reliability of records for suicide attempts in the database, especially going back over time.

[Table 3 about here]

Preliminary findings from the analysis were discussed at a meeting with Network Rail route representatives. This was a useful opportunity to check initial interpretations of the data and the relevance of the findings. Some gaps in the source material made it difficult to identify and classify some content in a moderate proportion of incidents, such as the point of access to the track. Additional information was provided by Network Rail (e.g. using headcodes - train identifying numbers) to help with classification of the line on which the fatality incidents occurred.

Analysis

The content of the dataset has been described. Descriptive statistics have been used to summarise the findings for each study area and for the whole sample of stations and connecting track areas, enabling comparisons across the three areas for each of the main study variables. Proportions have also been calculated for each variable. For example, the proportions of incidents that occurred at stations, on the open line and at other locations have been calculated and the variation across the three study areas has been assessed (e.g. differences in proportions of incidents at stations across the study areas). Gaps in the data sources have been identified (e.g. missing data on access points or train types). Findings have also been compared with reference data (e.g. from other published literature, Table 1). Cross-tabulation and Chi-square analyses have been used to investigate associations between age (<40, 40-60, >60), gender and the choice of location for suicide (stations or open line; fast lines or slower lines) and the impact of different lighting conditions (daylight, dark and dawn/dusk). Exploratory analysis has been used to examine trends (e.g. the numbers of incidents at stations by year). Narrative data from the SMIS database have been

classified, to identify standardised descriptions of immediate behaviours, precursor behaviours and contextual factors for each event. The immediate behaviour in this analysis relates to the last reported action that is described in the report (i.e. the behaviour that puts the person in a place of risk). Other references to behaviours prior to this are classified as precursor behaviours. There are many occasions within the reports in which short sequences of precursor behaviours are evident. Other descriptive content is often reported, such as the context in which an action takes place. The descriptions of the immediate and precursor behaviours and contextual factors have been represented in a tabular format, illustrating common groupings of behaviours in the period leading up to these events. The relative frequencies of behaviours prior to an event have been indicated.

Results

Types of incidents

Descriptive statistics were produced for all main variables (as listed above) and summarised in Table 4. The findings have been interpreted within the final column of this table.

[Table 4 about here]

Locations of suicide incidents

Of the 257 fatality events that have been selected for more analysis, approximately seventy percent of these occurred at stations, though there was quite a lot of variation across the three areas for this and many of the other variables. Fewer fatalities occurred on the open line and only one occurred at a crossing. The mainline crossings on these lines have been closed for a considerable time and the main access to the railway is at stations. Seventy percent of the incidents occurred on the fast lines, where trains do not stop at most stations. There is an approximately equal split of incidents in up and down directions (towards and away from London), but this varies across the routes. Differences could potentially be influenced by factors

such as the design of stations. For example, a line that is situated near to the station concourse might be chosen as it is the first platform which a person encounters. It was not possible to determine the lines on which incidents occurred in a small proportion of the events, due to the absence of descriptive information. There can still be a sizable proportion of events on slower lines (0.19-0.36), or not in the station (0.18-0.37). It is interesting to note that one of the incidents that occurred on a slow line was at night, at a station where the fast lines were under an engineering possession at the time. Therefore, the train involved in the incident was likely to have been a fast, non-stopping train, but diverted to travel on the slow line. This type of contextual detail was identified in discussions with industry staff and was not recorded in the database.

The access point to the track was commonly from the platform (more than two thirds of incidents). Access from the ramp at the platform end was only identifiable in up to 11% of these cases of access from the platform. It is not clear whether this represents the true proportion accessing the track in this way, or whether this reflects the lack of descriptive detail on the point of access in accounts of the incident. In around 6% of incidents access to the track was from a road bridge over the railway. Whilst there are references in the databases to access via gates, fences and footpaths in some incidents, in approximately 15% of the incidents it is not possible to classify the point of access with any confidence. It is important to note that the point of access may be some distance from the point of the incident (e.g. because a person may have crossed or moved along railway lines).

Whilst suicides commonly occurred at or near platforms in stations, there were several stations where there was a tendency for greater numbers of incidents outside of the station. In these cases, people may have moved out of the station to the point at which the incident occurred. It is possible that these were influenced by the availability of places of concealment, such as bridges or electrical cabinets, or due to the curvature of the track, enabling the person to hide before the approach of the train. Other factors that might have

influenced this included the location of built up areas nearby, access via road bridges and foot crossings and access to faster trains outside of the stations (i.e. at larger stations where more trains on fast lines stop, train speeds will be faster outside the station). It is also possible that differences might be explained by differences in record keeping (e.g. records were more detailed for fatalities at junctions or access points in some areas than in others).

Characteristics of stations

Table 5 shows how there were regular incidents at some lines at stations, in contrast with the apparently sporadic nature of incidents at other locations (e.g. where there has been a gap of several years between incidents). It is not known why incidents occur in some locations or at specific times and not others. As a result of the relatively small numbers of incidents at any particular location, it is also not known whether analysis of the historical data can give an understanding of future risk of incidents at a station or on a specific line.

[Table 5 about here]

The configuration of the stations has been considered. It is evident that there have been situations where access to the point of collision with the train has not been from an adjacent platform and it has been necessary to cross other lines to get to the point of impact. This has occurred in situations where a platform serving a fast line has been fenced off in an earlier intervention (Figure 2a) or where faster lines do not run close to platforms (Figure 1b and 2b). This type of behaviour (i.e. crossing lines) is not easily identifiable or recorded in the available data. Additional descriptive data relating to the station is needed to understand more about how people take the opportunity to get access to the track where they can and move to find the first, most convenient or fastest train. Movements around stations and the track area in this way clearly have implications for where and how to introduce an intervention (e.g. fencing or surveillance)

[Figures 2a and 2b about here]

Times of incident

There are higher numbers of off-peak events and this might indicate a desire for seclusion. However, as a note of caution, the analysis in the current study has not been conducted using equal time intervals, so a longer off-peak time period could contribute to the higher proportion of incidents. Most incidents occurred in the daylight in this study in Great Britain. Comparable data from other European countries such as the Czech Republic, Finland, Poland and Sweden, (see www.restrail.eu for more information about the RESTRAIL project) showed a greater tendency for night time incidents. The lower numbers of incidents at night or early morning and in darkness might be influenced by the fact that there are fewer trains during these periods and less frequent opportunities for these types of events.

Yearly trends

Preliminary analyses indicate that there may be an increase in the overall numbers of incidents over the years, a trend that is apparent in national data, as well as the data from these routes (Figure 3).

[Figure 3 about here]

There are indications of differences in the study areas, such as for numbers of incidents at stations, on the open line, or on fast and slow lines. These fluctuations that can be influenced by a range of factors. For example, one staff member suggested that lower numbers of fatalities in 2008 on one of the areas might be a result of the engineering blockages that occurred over that time period, with a reduction in train journeys. It is likely that the numbers of incidents over time might be sensitive to a variety of changes in the railway environment, including recent efforts to reduce suicides through a variety of fencing interventions and staff training. Reductions in incidents in recent years may be an indication of the success of these recent safety

interventions. However, there is need to be cautious about the interpretation of any trends, because of the relatively small numbers of incidents on these lines at these stations.

Evidence on other influencing factors

Two thirds of those involved were male, in cases where gender was recorded. Records for age are presented (Table 4), but details were missing in forty percent of the events. Analyses demonstrated no association between gender and choice of location or the time at which the events occur (Table 4). There is an indication that the older age group (>60) have been involved in more events than would have been expected on slower lines, but these findings should be treated with some caution, given the gaps in the data on age.

Mental health issues were identified in a relatively small proportion of the incidents. The analysis also demonstrates that little is recorded about other medical or social issues that may have influenced the events. These findings might be indicative of gaps in reporting, rather than providing reliable information on the health status of those involved.

Witnesses to the events have been classified (Tables 3 and 4). Drivers were the most common witnesses and often the only witnesses (according to details in the records), especially for incidents on the open line. It was often not easy to identify from the records whether events occurred on crowded or isolated platforms. In determining whether isolation could be an influencing factor, it is worth investigating whether the numbers of incidents are different at staffed and unstaffed stations. However, more site specific details would be needed to understand the potential effects of having platform staff, booking office staff or no staff at a station.

The train type is only identifiable in the databases for approximately half of the incidents (Table 4). There is considerable variation in the type of train that is recorded and this might be explained by differences in

recording in databases on different rail routes. The findings do not present conclusive evidence of the choice of high speed trains for rail suicide.

Behaviours of people prior to incidents

It has been possible to identify some common patterns of access to the track, describing the immediate mode of access and precursor behaviours, using a set of standardised terms. Sequences of behaviour and other descriptive content from the narrative reports in the database are shown in a series of Tables. Table 6a shows the most common immediate behaviour of jumping or stepping from the platform into the path of the train (86 of these incidents) and the range of precursor behaviours that preceded this immediate behaviour. These precursor behaviours have been classified into categories of movements, waiting behaviours and looking / searching behaviours. Additional descriptive data are also presented (e.g. how actions were described or reports of warnings from the driver's horn). The precursors show evidence of visual indications of risk (e.g. standing close to the platform edge), which could be used to help plan better safety interventions. The analysis was also sensitive enough to pick up an indication in one event that a person might be hesitating prior to getting access to the track (i.e. stepping back temporarily). More extensive interpretations of the content of these sequences of behaviour are shown in the final column of Table 6.

Other immediate behaviours are shown in Tables 6b to 6d. These include descriptive details of how people waited on the track for the arrival of the train, movements around the track area in front of the train and a number of less common modes of access to the train or other causes of death. Similar analyses have been conducted to describe the range of precursor behaviours and contextual factors that are noted within the reports. Gaps in the data are also evident. For example, it was not possible to classify the immediate behaviour in 40 of the 257 events. In a small number of these the witness (usually the driver) had noticed

some earlier behaviour (e.g. jumping on the line, standing close to the edge), but they were not able to say more about what happened immediately before impact.

Overall, this type of analysis helps to summarise the range of behavioural and contextual details for a wide range of events. The analysis illustrates the most common and unusual behaviours and circumstances in this sample of incidents. The contents of Tables 6a to 6d help to explore pathways or common sequences in behaviours during incidents. These give some insight into the sudden or impulsive nature of some of these events, in comparison with the more deliberative and planned nature of others. Time is not shown explicitly in the analysis, but this can be inferred from the content and can inform decisions on the types of prevention measures that may be appropriate (e.g. there is little time to intervene when someone moves from behind an object and jumps into the path of the train). However, it might be hard to separate some of these observed behaviours from other behaviours of passengers that can be seen at stations.

[Table 6 about here]

Discussion

This study has examined a substantial set of incidents over a lengthy time period, covering a wide range of station types. These are based on events from locations near to 51 of the 2500 stations nationally and, by nature of their locations, expand knowledge of the characteristics and factors that could influence suicide incidents at and in the vicinity of mainline stations in Great Britain. They are less likely to reflect conditions on other commuter or more rural branch lines with greater numbers of crossings, alternative access points to the railway and differences in train service and stopping patterns. Furthermore, these findings may not generalise well to situations in other countries. Nevertheless, the analysis has investigated a good range of incidents, using a combination of simple descriptive statistics and analysis of narrative content.

This research has considered the potential value of different types of information (e.g. Table 1 for potential influencing factors for rail suicide). This analysis has produced a better understanding of the type of content that is available in sources that are accessible to rail organisations, including appraisal of the effort that is needed in identifying, collating and analysing the data. The industry may need to consider where future work is targeted on the study of different factors. Mishara and Bardon [4], on the basis of their systematic review of a wide of previous research, consider that there may be little to learn from more descriptive epidemiological studies covering the same variables. The current study has shown what is accessible when planning to examine a wide range of variables (e.g. locations, time, mental health, train type, level of seclusion or crowding on platforms). The study also had the motivation to look more widely for new factors that can be considered. There are limitations in some of the existing sources of data, including the detail that is available, the precision of the content, missing content and differences in details in databases and other sources of information. There will be value in conducting detailed analysis of the content that is embedded within the narrative fields in the SMIS database (e.g. the line on which the incident occurred), though some effort is needed in extracting, verifying, supplementing and coding the content for the analyses. However, the descriptive details are often limited and additional information may be available from other sources (e.g. Network Rail and British Transport Police data).

On balance, the industry database gives a good understanding of how many incidents occur and, to a limited extent, where these occur (e.g. at or near to specific stations). Preliminary comparisons have been conducted across data from different routes. This has demonstrated the variation across these rail routes for a number of different variables and how national proportions do not reflect local situations. As an example, it has been reported how around 40 per cent of suicides occur at stations [1], and it might be reasonable to expect that strategies for safety interventions could be developed with this in mind. However, the analysis has shown that the proportions of incidents at stations can be much higher and are likely to vary on different parts of the network. This type of variation can occur for a number of situational,

geographical, cultural and individual reasons. The practical significance of these differences needs more consideration, especially how it will influence the planning of safety prevention measures at these locations.

The current analysis has shown that it is important to understand precise details of the location of the incident, especially getting clarity on the line of the incident, the point of access and behaviours such as crossing of other lines to reach the point of contact with the train. It is often hard to identify from the records exactly where the incident occurred (i.e. where in the station, how far from the station and on which line). Furthermore, it is clear that multiple locations are important; the place of access is different to the place at which someone is struck and these can be different to the place at which the body is found or at which the train eventually stops. These differences are all likely to contribute to imprecision or errors in organisational records and related statistics. Currently, these details are not collected and recorded systematically in the industry. Even if these are known, these are hard to identify from narrative content of the database. Useful information was obtained in this study by collecting additional information from industry staff, helping with understanding of what really happened within an incident (e.g. a fast train operating on a slow line in one of the cases). More work is needed to make this type of local knowledge more widely accessible within industry records.

Relatively little is also known about how events occur. There are gaps in knowledge of events and this is a weakness when considering the best approaches to prevention. Whilst these are clearly very serious events, involving loss of life and major disruption to train services (with high averages costs and annual costs to the industry [39]), these have not typically been subject to the type of investigation that occurs when other serious incidents and fatalities occur on the railway [40]. There are examples of good practice in the industry (e.g. serious incident reviews, carried out where there has been extensive delay arising from an incident) and use of a psychological autopsy study to collect in-depth knowledge of the events [41]. There will be value in broadening the scope of investigations, based on best practice for incident

investigation [42]. This could include conducting investigations around a suitable model of accidents or events, using an appropriate taxonomy to structure the collection and analysis of data and ensuring that learning takes place within and across relevant organisations and stakeholders.

The study has contributed to understanding of patterns of immediate and precursor behaviours. The identification and representation of the immediate behaviours associated with the events adds depth to earlier classifications that are available in the literature on the modes of access to the track (e.g. the study of behaviours such as jumping, lying and wandering on the track [24], [25]). The precursors have been found to have common features; covering the movements, waiting behaviours and searching behaviours of the people involved in these incidents. The analysis gives an indication of the relative frequencies of common types of events and behaviours, as well as the locations in which they occur, going beyond the anecdotal reports in some of the earlier published sources [15], [22]. For example, the findings demonstrate the very late and often sudden movements from platforms into the path of the train in a high proportion of incidents (86/257). The content shows the determination of those involved (pushing past people). There is also a high proportion of incidents where people are in the track area for a longer period of time (105/257). These include movements along and across the track and efforts to search for trains, before standing, crouching or lying down to make contact with the train. The analysis has also identified less common incidents (e.g. sitting on the edge of the platform, leaning into the path of the train). Each, the more common and the unique, present different challenges for prevention. The detailed, descriptive findings provide knowledge that is fundamental to the correct specification of recommendations for prevention (e.g. through use of physical barriers, station design, interventions by people). However, in spite of efforts to collect and analyse the detail, it is notable that the reports often contain relatively little descriptive details. It was not possible to conduct this type of analysis for forty of the events. The distinguishing features of some incidents may provide useful lines of enquiry and could be used as prompts for the routine collection of better data in future analyses of these types of events. It should be noted that this analysis of the text has

been conducted by a single analyst and further work is needed to consider the reliability of the classification [43], including extension of this work to cover a wider range of incidents at different types of locations.

A wide range of factors that can influence railway suicide events have been considered in this study. Table 7 includes a brief overview of conclusions from the review of literature and the analysis of the data in the current study, also offering new guidance for improvements in the collection and use of data on a range of relevant variables associated with railway suicide.

[Table 7 about here]

Conclusion and future work

There is a lot of information on rail suicide events recorded and available to the industry. Some types of information may be more useful than others in explaining the incident. The study has shown how important new knowledge can be uncovered from a detailed analysis of the data and through incorporation of local knowledge from staff in the industry, giving a new perspective to some details in the data. The value of qualitative analysis of text and descriptive data has been illustrated, as well as the need to go beyond basic presentation of statistics, which on their own can give misleading or incomplete descriptions of the events and circumstances surrounding the fatalities. More could be learned about the nature of the problem with more in-depth investigation and analysis of incidents as they occur, improvements in recording of some type of information and sharing of important lessons. New guidance has been offered for improvements in data collection on a range of variables.

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References

[1] RSSB. *Annual Safety Performance Report 2014/15.* Rail Safety and Standards Board, UK, 2015.

[2] ERA. *Railway safety performance in the European Union 2014.* European Railway Agency, France, 2014.

[3] Krysinska K and De Leo D. Suicide on railway networks: Epidemiology, risk factors and prevention. *Aust N Z J Psychiatry* 2008; 42(9): 763-771.

[4] Mishara BL and Bardon C. Systematic review of research on railway and urban transit system suicides, *Journal of Affective Disorders* 2016; 19: 215–226.

[5] Too LS, Milner A, Bugeja L, McClure R. The socio-environmental determinants of railway suicide: a systematic review, *BMC Public Health* 2014; 14:20.

[6] Hepp U, Stulz N, Unger-Köppel J and Ajdacic-Gross V. Methods of suicide used by children and adolescents. *European Child & Adolescent Psychiatry* 2012; 21(2): 67-73.

[7] Cooper P, and Milroy C. Violent suicide in south Yorkshire, England. *Journal of Forensic Science* 1994; 39(3): 657-67.

[8] Kerkhof A. Railway suicide: Who is responsible? Editorial. *Crisis: The Journal of Crisis Intervention and Suicide Prevention* 2003; 24(2): 47-48.

[9] van Houwelingen C, Kerkhof A and Beersma D. Train suicides in the Netherlands. Journal of Affective Disorders 2010; 127: 281-286.

[10] Andriessen K and Krysinska K. Railway suicide in Belgium 1998-2009. *Crisis: The Journal of Crisis Intervention and Suicide Prevention* 2011; 26:, 1-7.

[11] Niederkrotenthaler T, Sonneck G, Dervic K, et al. Predictors of suicide and suicide attempts in subway stations: a population-based ecological study. *J. Urban Health* 2012; 89(2): 339–353.

[12] Tseloni A, Evans E, Brown R. *Modelling Railway Suicides in Great Britain: 2003–2010.* RSSB, London, 2011.

[13] Huisman A, van Houwelingen CA and Kerkhof AJ. Psychopathology and suicide method in mental health care, *Journal of Affective Disorders* 2010; 121: 94-99.

[14] Bhui K, Chalangary J and Jones E. *Rail suicides in the UK: Risk factors and prevention strategies,* Cultural Consultation Service, UK, 2013,.

[15] O'Donnell I, Farmer R and Catalan J. Explaining suicide: The views of survivors of serious suicide attempts. *British Journal of Psychiatry* 1996; 168: 780.

[16] Mohanty MK, Panigrahi MK, Mohanty S and Patnaik KK. Death due to traumatic railway injury. *Medicine Science and the Law* 2007; 47(2): 156-160.

[17] Cocks R. Study of 100 patients injured by London underground trains 1981-6. *British Medical Journal* 1987; 12: 1527-1529.

[18] De Leo D and Krysinska K. Suicidal behaviour by train collision in Queensland, 1990-2004. *Australian and New Zealand Journal of Psychiatry* 2008; 42(9): 772-779.

[19] Beskow J, Thorson J and Öström M. National suicide prevention programme and railway suicide. *Social Science & Medicine* 1994; 38(3): 447-451.

[20] Lukaschek K, Baumert J and Ladwig K. Behaviour patterns preceding a railway suicide: Explorative study of German federal police officers' experiences. *BMC Public Health* 2011; 4(11): 620.

[21] Shapiro MJ, Luchtefeld WB, Durham RM and Mazuski JE. Traumatic train injuries. *The American Journal of Emergency Medicine* 1994; 12(1): 92-93.

[22] Clarke R and Poyner B. Preventing suicide on the London underground. *Social Science & Medicine* 1994; 38(3):, 443-446.

[23] Ryan, B. Reducing suicide and trespass in rail – Developing better interventions through understanding of behaviours of people. *Proc IMechE Part F: Journal of Rail and Rapid Transit* 2013; 227(6): 714 – 722.

[24] Guggenheim FG and Weisman AD. Suicide in the subway. Publicly witnessed attempts of 50 cases. *Journal of Nervous and Mental Disease* 1972; 155: 404-409.

[25] Dinkel A, Baumert J, Erazo N and Ladwig KH. Jumping, lying, wandering: Analysis of suicidal behavior patterns in 1,004 suicidal acts on the German railway net. *Journal of Psychiatric Research* 2011; 45: 121-125.

[26] O'Donnell I and Farmer R. The epidemiology of suicide on the London underground. *Social Science & Medicine* 1994; 38(3): 409-418.

[27] Erazo N, Baumert J and Ladwig KH. Sex-specific time patterns of suicidal acts on the German railway system. An analysis of 4003 cases. *J. Affective. Disorders* 2004; 83 (1):1–9.

[28] Ladwig KH, Ruf E, Baumert J and Erazo N. Prevention of metropolitan and railway suicide. In: Wasserman D and Wasserman C (eds.) *Oxford textbook of suicidology and suicide prevention*. Oxford: Oxford University Press, 2009, pp. 589-594.

[29] Ajdacic-Gross V, Bopp M, Ring M, et al, Seasonality in suicide – A review and search of new concepts for explaining the heterogeneous phenomena, *Social Science and Medicine* 2010; 71: 657-666.

[30] van Houwelingen C. and Beersma D. Seasonal changes in 24-h patterns of suicide rates: A study on train suicides in the Netherlands. *Journal of Affective Disorders* 2001; 66: 215-223.

[31] Lukaschek K, BaumertJ, Erazo N and Ladwig KH. Stable time patterns of railway suicides in Germany: comparative analysis of 7187 cases across two observation periods (1995–1998; 2005–2008). *BMC Public Health* 2014; 14 (1): 124.

[32] Erazo N, Baumert J and Ladwig KH. Factors associated with failed and completed railway suicides. *Journal of Affective Disorders* 2005; 88: 137-143.

[33] Rådbo H, Svedung I and Andersson R. Suicides and other fatalities from train-person collisions on Swedish railroads: A descriptive epidemiologic analysis as a basis for systems-oriented prevention. *Journal of Safety Research* 2005; 36(5): 423-428.

[34] Rådbo H and Andersson R. Patterns of suicide and other trespassing fatalities on state-owned railways in greater Stockholm; implications for prevention. *International Journal of Environmental Research and Public Health* 2012; 9: 772-780.

[35] Savage I. Analysis of fatal train-pedestrian collisions in metropolitan Chicago 2004–2012, *Accident Analysis and Prevention* 2016; 86: 217–228.

[36] Abbott R, Young S, Grant G, et al. *Railway suicide, an investigation of individual and organisational consequences*. Sheffield: Doncaster and South Humber Healthcare NHS Trust, 2003.

[37] van Houwelingen CAJ, Baumert J, Kerkhof A, et al. Train suicide mortality and availability of trains: a tale of two countries. *Psychiatry Research* 2013; 209 (3): 466–470.

[38] Hegerl U, Koburger N, Rummel-Kluge C, et al. One followed by many? Long-term effects of a celebrity suicide on the number of suicidal acts on the German railway net, *Journal of Affective Disorder 2013*; 146(1): 39-44.

[39] Taylor A, Knipe D and Thomas K. Railway suicide in England and Wales 2000–2013: a time-trends analysis. *BMC Public Health* 2016; 16: 270.

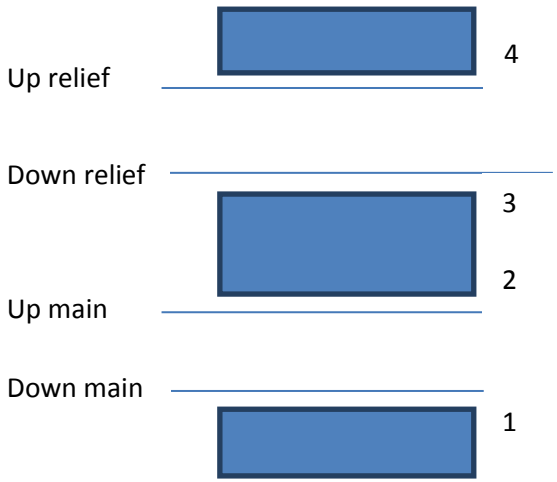
[40] RSSB. *Reporting of Safety Related Information*, Railway Group Standard, GERT 8047, RSSB, December 2013.

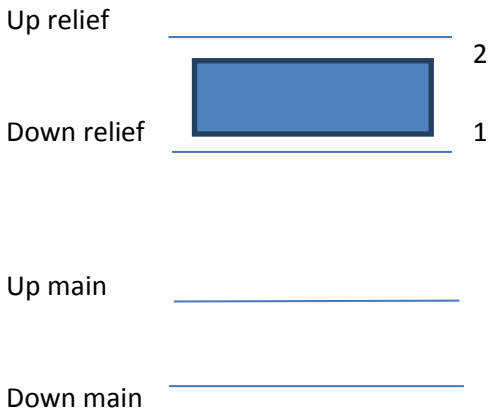
[41] Berman A, Sundararaman R, Price A, et al. *Defining Characteristics of Intentional Fatalities on Railway Rights-of-way in the United States, 2007–2010.* US Department of Transportation, Washington, DC, 2013.

[42] Ryan B. Incident reporting and analysis. In: Wilson JR and Sharples S (eds) *Evaluation of Human Work*, 4th ed. UK: CRC Press, 2015, pp821-836.

[43] Olsen N. Reliability studies of incident coding systems in high hazard industries: A narrative review of study methodology. *Applied Ergonomics* 2013; 175-184.

Figure 1 Plan view of station with platforms accessing all main (fast) and relief (slow) lines (1a) and showing direct access to relief (slow) lines only (1b)





Figures 2a and 2b Photographs showing where a platform serving a fast line has been fenced off in an earlier intervention and where faster lines do not run close to platforms

Figure 3 Frequencies of fatality incidents by year across the locations in the three areas of the study, also showing the numbers of suicides nationally on the railway by year

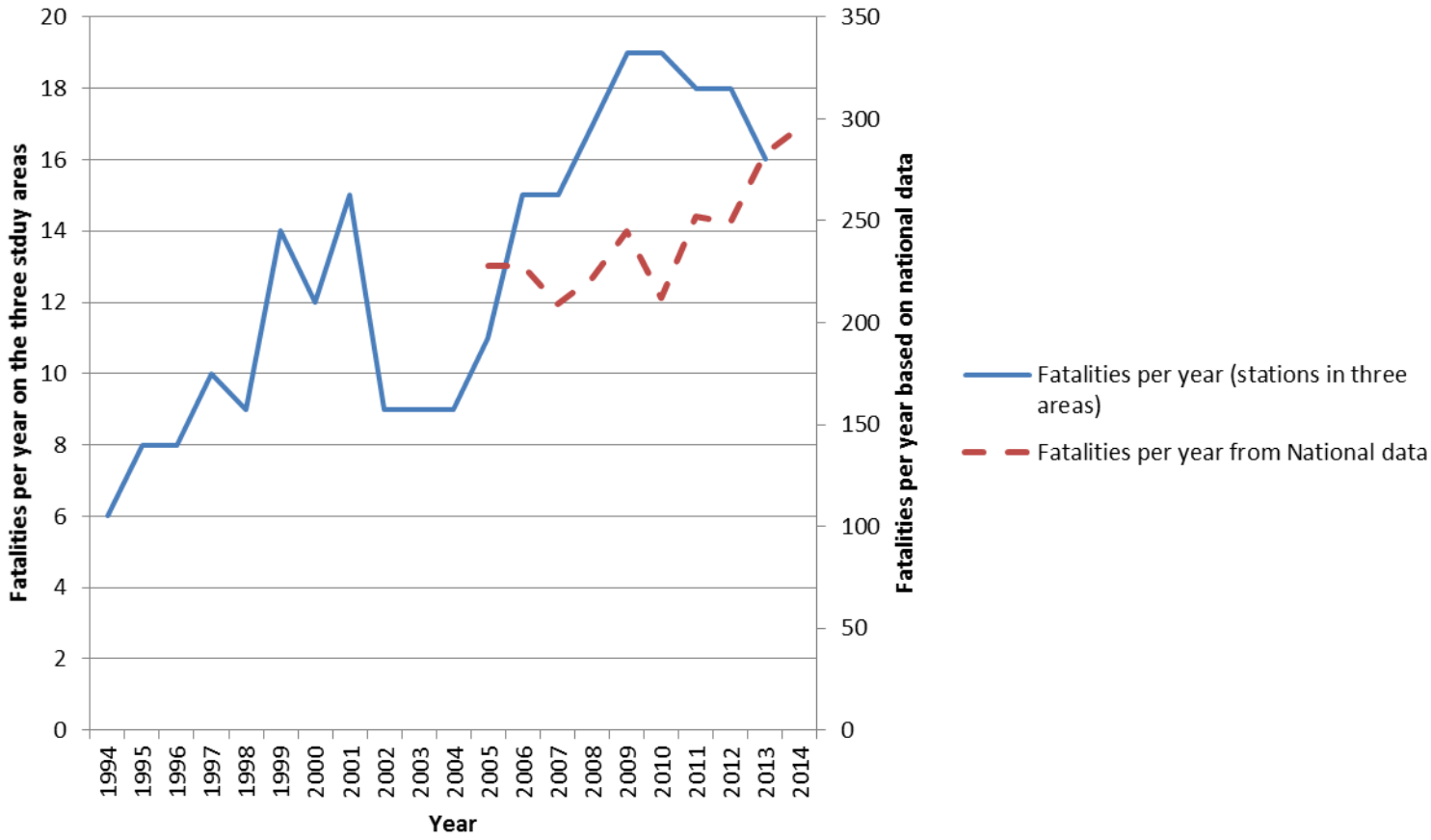


Table 1 Summary of findings from studies investigating factors affecting railway suicide

Factor	Evidence from Literature
National fatalities and Fatality rate	Varying from 11 in a year in Australia to 936 in Germany [4]. Railway suicide attempts do not always result in fatality (e.g. due to train speed, the design of trains to lessen the impact and better sighting at some locations to enable stopping [4]). 14 studies were reviewed with fatality rates from 42.4-92% fatality [3].
Railway suicides as a proportion of national suicides	Railway suicides represent a relatively small proportion of national suicides. 12 studies were reviewed with rail suicide as a proportion of national suicides varying from 1% to 12% [3].
Age	There is an indication that younger people are more likely to choose this type of violent death [6], [7], [8]. The higher proportions of younger people choosing this method might be explained by impulsiveness or the difficulty in accessing other means of suicide, such as using medication [9]. There are various descriptions of age distributions, where the dominant age group is in the years 40-60 [4], though there are still large numbers of younger and older people taking their lives in this way.
Gender	There is a slight male dominance [10], [11], though the degree of this varies across studies e.g. 16 studies were reviewed with male to female ratio 1.1:1 to 9:1 [3]; 8 studies with male to female ratio 1.55:1 to 3.78:1 [4]).
Marital status	The marital status of those committing suicide differs across studies from Canada, USA and Australia. Whilst it has been suggested that being married can reduce the risk of suicide there are still sizeable proportions of people who are married or in relationships committing suicide [4].
Socioeconomic status	There may be some relationships with unemployment, living alone, communal living or temporary housing [3], [4]. It can be difficult to find relationships involving socioeconomic data and suicides at railway locations (e.g. these were not clearly established in the UK [12]), though there were some links between indicators of lower socioeconomic status and metro suicides [4].
Health status (including mental health)	A good number of studies show associations between suicide and psychiatric problems [4]. People with bipolar affective disorder were found to be more likely to choose rail suicide as it is perceived to be sudden death, and there are also links to impulsiveness [13]. However, there are other studies that show a high proportion of rail suicides involving people without any history of psychiatric care [14]. Other factors such as loneliness, ending of relationships, depression and anxiety, worries about financial problems are potential influencers [15]. Drugs and alcohol can play a part, but there is variable evidence so far (e.g. from 2% involving intoxication [16], 10% [17], 20-30% [18], [19], [20], 70% [21], [22].
Precipitating factors	Factors thought to trigger a suicide event include use of alcohol or drugs, disputes with partners / family, changes in emotions, stopping medication, legal problems or sources of humiliation [4].
Suicide threats and previous attempts	In some studies, high proportions of those involved have made previous attempts or serious threats to kill themselves. These figures vary a lot between studies (possibly because this type of data is not easily recorded) (from 2% to 81% across several studies [4]). It has been suggested [4] that this is indicative of forethought and planning in many suicides.
Behaviour immediately before suicide attempts	There have been a few studies in this area, identifying a range of behaviours or actions (e.g. dropping bags or leaving possessions, removing shoes, having personal items, avoiding eye contact, erratic gestures, wandering aimlessly, unusual clothing, movements at stations [15], [20], [22], [23]. Different modes of access to the railway have been classified (e.g. jumping, lying, wandering on the tracks [24], [25]). These studies generally lack detail about the collection and description of the behaviours, but contain simple accounts or classifications of actions. These frequently relate to behaviours which occur very close to the point of collision and may have limited value in terms of prevention.

Factor	Evidence from Literature
Timing - Seasonal and monthly variations - Weekly variations - Hourly variations	There appear to be either no effects, very small or variable effects of seasons / months of the year [26], [27], [28], [29]. Some peaks and periods with lower numbers have been identified in various countries [4]. There may be more rail suicides at the beginning of the week (possibly triggered by concerns about work) and lower numbers at weekends [27], [30], [31]. In one study, peaks have been identified shortly after sunset and a second peak approximately ten hours earlier, shifting with sunset time [30]. Another study shows other peaks in numbers (e.g. between 9 and 12 in the morning and 6 and 9 in the evening, with higher mortality at night time [32]). Numbers might be influenced by times when people are travelling or accessing the station and when there is a greater frequency of trains. If a higher risk time could be established this might help with planning interventions (e.g. scheduling security patrols).
Geography of railway suicides - Proximity of residence - Clusters and hotspots - Proximity of mental health services - Population and railway traffic density - Location on railway property	Suicides generally occur where people can get access (e.g. at stations and crossings, where the railway is largely fenced elsewhere) [9], often in densely populated areas [33]. In more rural areas, access is usually via level crossings or at bridges or near tunnels [34]. There are locations where there are greater frequencies (possibly where fencing is poorer or close to psychiatric institutions) [9], [10]. Definitions of what involves a cluster or hotspot vary [4]. In several countries it is clear that some stations or locations have greater proportions of events than others (e.g. 54% of suicides on 12% of the network) [9]. Data have been presented which compare numbers of incidents at stations, crossings and open line across 5 countries (e.g. in UK 39% at stations, 47% on the open track and 12% at crossings) [4]; in Germany, three times more suicide attempts occurred on open lines than stations [27] and fast track lines were correlated with higher mortality. Intentional deaths are more prevalent on lines with frequent passenger trains [35]. Events usually occur close to home [36], [8]. Higher rates of suicides were found when stations were crowded, when there were faster trains and when high risk groups were attracted to these stations [11]. In one study [9] it was found that railway parameters (e.g. numbers of train passengers, frequency of trains, passenger kilometres, train kilometres, railway density, familiarity with the railway) and population parameters (population density) did not influence suicide numbers at a regional level in the Netherlands. In a later study train frequency and population density did have an association with rail suicides in the Netherlands and Germany [37]. In a systematic review of socio-environmental determinants of railway suicide positive associations were found involving train frequency, faster trains, distance to historical sites, railway length, growth of railway length, numbers of train passengers, population density [5].
Knowledge of previous events	Family members may be at increased risk of suicide after the death of a family member by suicide [14]. Several studies have reported on the increase in events after reporting of a rail suicide of a famous person [38] and there have been clusters of suicide following from a highly publicised event) [35]. 70% of suicides are not associated with copycat incidents [35].

Table 2 Descriptive details of the three areas in the study

	Location		
Descriptive detail	**Area L**	**Area S**	**Area W**
No. of stations	23	8	20
Approximate geographical length of track	75 miles, running north west from London	10 miles, running south from London	50 miles, running west from London
Descriptions of stations within the area	Two large stations with 6 platforms and 6 million users (National Rail entry and exit figures). Twenty one small to medium urban and rural stations (0.07-2.8 million users), with 2-6 platforms 5-11 non-stopping trains per hour on fast lines on this route.	One large station with 6 platforms and 20.9 million users. Eight small to medium urban stations (0.6-3.7 million users), with 4-6 platforms. 4-16 non-stopping trains per hour on fast lines on this route.	One very large station with thirteen platforms and 15.4 million users per year. There are few non-stopping passenger trains at this station. One large station, with six platforms and 5.6 million users. Seventeen smaller, urban and rural stations, with between 2-4 platforms and 0.2 to 5.3 million users. 9-19 non-stopping trains per hour on fast lines on this route.

Table 3 Outline of the variables, category breakdown and details of method of analysis

Variable and description of data available	Source, rationale and methods of classification
Location: Crossing; Open line; Station; Train; Not known	To determine the location of events (e.g. in station, out of station, part of the platform if possible). The classification looked initially at the classification in the SMIS database, but also cross-checked this with detail in the narrative field of the database. Determination of whether the event was in station (including the approach to and the exit from the station) was done using data in the narrative text field.
Station Selection from 51 stations within the 3 study areas	The event is associated with the nearest station, based on information within the SMIS database. It is recognised that the event can occur outside the station (see the location field).
Line on which the incident occurred: Faster **(**Down fast / Down main, Up fast / Up Main); Slower (Down relief / Down slow, Up relief / Up slow, Down DC (electric), Up DC (electric), Other); Not known; Not relevant	This was not classified in the database, so was identified from the narrative text field and with supplementary data from railway staff where necessary using the identification headcode for the train involved. There are some different naming conventions for lines on different rail routes. The category "not relevant" was used in the small number of cases where the event was not connected to collision with a train or touching of the power supply.
Place of access: Platform; Platform end; Bridge; Other access point (Access gate; Crossing; Embankment; Footpath; From a train; Lineside fence; Road); Not known	This was not classified in the database, so was identified from the narrative text field, where sufficient information has been available.
Time of the event: Time of incident (Hours / minutes); Day of the week; Month of the year; Year (from 1994-2013); Not known	The time and date of the incident is listed in the SMIS database. Additional categorical fields were established for day, month and year for analysis in this study. Occasionally, the time of the event is unknown (e.g. in circumstances where a driver may notice a body on the track, resulting from an earlier event).
Time classification: Evening peak; morning peak; night, early morning; off-peak; Not known	Classification, based on time of day, with evening peak 4.00pm to 8.00pm, morning peak 5.00am to 9.00am, off peak 9.00am to 4.00pm and night / early morning 8.00pm to 5.00am.
Daylight / visibility: Dark; Dawn and Dusk; Daylight; Other (in tunnels, on train); Not known	Data on time / date has been used to classify the lighting conditions, using a web-based calculator http://www.timeanddate.com/sun/uk/london.
Train type: Freight; Freight – intermodal; Loco hauled/push-pull passenger; Parcel train; Passenger diesel multiple unit; Passenger electric multiple unit; Passenger High Speed Train; Passenger multiple unit; Not known	Classification of train type has been based on the pre-existing classification for train type in the SMIS database.
Witnesses, crowding: Open line –Driver and other rail staff; Police / security / emergency staff witnesses; Public / passenger witnesses; not known Station –Driver and other rail staff; Police / security / emergency staff witnesses; Public / passenger witnesses; not known	Classification of witnesses to the event is based on content from the narrative text field in SMIS.
Mental health: Mental health issues (depression and various non-specific issues); In-patients or out-patients at a psychiatric hospital; Previous suicide attempt or threat; not known	The classification is based on the field for personal circumstances from SMIS, plus other contents of the narrative field in SMIS.
Other social and health related: drugs / alcohol; family link to previous suicide; finance / loss of livelihood / homeless; legal / suspected of serious crime; multiple factors (finance, drugs alcohol); other medical problems; Relationship problems; not known.	The classification is based on the field for personal circumstances from SMIS, plus other contents of the narrative field in SMIS.
Gender: Male; female; not entered	Data from the field in SMIS. Cross-tabulation and Chi-square analysis to examine association between gender and location and lighting conditions.
Age: Count of events where age recorded **(**Age if known, otherwise apparent age entered as a range); count of not entered; mean, sd by area, range.	Data from the field in SMIS. Cross-tabulation and Chi-square analysis to examine association between age and location and lighting conditions.
Behaviour	Classification of sequences of immediate and precursor behaviours, plus other descriptive content and factors affecting behaviours, based on the narrative content from SMIS.

Table 4 Overview of the findings for different data types for three study areas, including overall results and the variation across the separate areas (based on N=257, unless otherwise stated)

Variable	Numbers of incidents				Proportion of incidents (upper and lower limits)	Interpretation
	Area L	Area S	Area W	Total		
Location						
Incidents at:						The proportion of events at stations is higher than reported previously in national data for stations [4]. There is variation across the samples from the three study areas.
Stations	67	28	88	183	0.71 (0.63-0.82)	
Crossings	1	0	0	1	0.00 (0.00-0.01)	Only one event occurred at a crossing (most crossings have been closed on these lines for a considerable period of time).
Open line	38	6	28	72	0.28 (0.18-0.36)	
On trains	1	0	0	1	0.00 (0.00-0.01)	There was no association between age/gender and choice of location (stations or the open line) for suicide.
Line on which the incident occurred						There is a dominance of fast line events, especially within stations. However, there are an appreciable number of events occurring on slower lines.
Incidents on:						
Fast lines	64	25	91	180	0.70 (0.60-0.78)	In approximately 4% of cases it was not possible to establish the line on which the incident occurred. There was no association between gender and the choice of fast or other lines for suicide. More people than would have been expected in the age group over 60 were involved in suicides on the slower lines (Pearson Chi-square 9.055, df 2, p=0.011).
Other lines	39	7	22	68	0.26 (0.19-0.36)	
Line not known	4	2	3	9	0.04 (0.03-0.06)	
Incidents at stations (N=183):						
Fast line events	38	22	75	135	0.74 (0.56.0.85)	
Other lines	26	4	10	40	0.22 (0.11-0.39)	
Line not known	3	2	3	8	0.04 (0.03-0.07)	
Place of Access						
Access from the platform [platform end]	68 [7]	28 [5]	90 [9]	186 [21]	0.69 (0.56-0.85) 0.08 (0.07-0.11)	Access is predominantly from a platform. The records indicate that there has been limited access from the platform end across the sample areas. It is not known if this reflects true access rates from this location or whether accurate details on the point of access are not known or not recorded in the database. There was access from a bridge in a small number of cases. It was not possible to determine any access point in around 15% of the cases.
Access from a bridge	9	0	7	16	0.06 (0-0.09)	
Other access point	11	1	4	16	0.06 (0.03-0.1)	
Access point not recorded	19	5	15	39	0.15 (0.13-0.18)	
Day of the week						
Monday	17	4	20	41	0.16 (0.12-0.17)	A smaller proportion of incidents occurring on a Sunday might be accounted for by fewer trains and passengers on account of the weekend timetable. Slightly higher numbers occurring at the beginning of the week and fewer at the weekend are consistent with some earlier studies in the literature [27],[30], [31].
Tuesday	13	4	16	33	0.13 (0.12-0.14)	
Wednesday	21	4	13	38	0.15 (0.11-0.2)	
Thursday	10	10	16	36	0.14 (0.09-0.29)	
Friday	21	5	15	41	0.16 (0.13-0.2)	
Saturday	16	4	18	38	0.15 (0.08-0.15)	
Sunday	9	3	17	29	0.11 (0.08-0.15)	
Not known	0	0	1	1	0.00 (0.00-0.01)	
Month of the year						
January	9	2	9	20	0.08 (0.06-0.08)	There are some differences evident by month, though the seasonal / monthly effects in the literature have been found to be different across countries [4]. In the current study the numbers were lowest in June and August, and highest in July and September. There is quite a lot of variation across the study areas.
February	5	3	12	20	0.08 (0.05-0.1)	
March	13	2	6	21	0.08 (0.05-0.12)	
April	10	5	9	24	0.09 (0.08-0.15)	
May	11	6	4	21	0.08 (0.03-0.18)	
June	5	0	10	15	0.06 (0.00-0.09)	
July	12	1	16	29	0.11 (0.03-0.14)	
August	7	3	7	17	0.07 (0.06-0.09)	
September	11	4	14	29	0.11 (0.1-0.12)	
October	8	3	10	21	0.08 (0.07-0.09)	
November	6	1	13	20	0.08 (0.03-0.11)	
December	10	4	6	20	0.08 (0.05-0.12)	

Time classification						
Day time off peak events	53	16	51	120	0.47 (0.44-0.5)	The highest proportion of incidents occurred off-peak, perhaps when stations were less crowded, though there is need for some caution in interpreting these findings as they are based on unequal time periods (i.e. shorter peak time periods, longer off peak and night time hours).
Events at night or early morning	22	7	28	57	0.22 (0.21-0.24)	
Events at evening peak	19	10	22	51	0.20 (0.18-0.29)	
Events at morning peak	13	1	14	28	0.11 (0.03-0.12)	
Not known	0	0	1	1	0.00 (0.00-0.01)	
Daylight / visibility						
Events in daylight	75	26	73	174	0.68 (0.63-0.76)	The majority of incidents occurred in hours of daylight. Lower numbers occurred in the dark, potentially influenced by fewer trains running at night time and more difficult access to trains. The findings are not indicative of the type of peak at sunset that has been identified in earlier work [30] and are not easily comparable with other analyses in the literature, which show peaks in mid-morning and evening [32]. There was no association between gender/age and the choice of suicide in different lighting conditions (e.g. daylight, dark, dawn / dusk).
Events in the dark	22	4	28	54	0.21 (0.11-0.24)	
Events at dawn and dusk	8	4	13	25	0.1 (0.07-0.12)	
Other events (in tunnels, on train)	2	0	0	2	0.01 (0-0.02)	
Not known	0	0	2	2	0.01 (0-0.02)	
Train type						
High speed passenger train	6	0	33	39	0.15 (0-0.28)	Only a modest proportion of records specifically recorded the involvement of high speed trains, though in practice many of the train types will travel at a high line speed. The train type was not recorded in almost half of the incidents
Passenger multiple unit	29	19	35	83	0.40 (0.33-0.79)	
Freight train	7	0	2	9	0.04 (0-0.08)	
Other train (parcel, loco-hauled passenger)	2	0	0	2	0.01 (0-0.02)	
Not known	63	15	46	124	0.48 (0.4-0.59)	
Witnesses, crowding						
People witnessing events at:						
Stations						
Driver and other rail staff	50	23	70	143	0.78 (0.75-0.82)	In the majority of cases these events were only witnessed by the driver. The absence of other witnesses could indicate that the events did not occur on crowded platforms, though this might also be indicative of incomplete recording of any witness details.
Police, security or emergency staff	1	0	0	1	0.01 (0.00-0.01)	
Public or passenger witnesses	1	2	8	11	0.06 (0.01-0.09)	
No witness recorded	15	3	10	28	0.15 (0.11-0.22)	
Open line						
Driver and other rail staff	18	6	14	38	0.53 (0.47-1.00)	
Public or passenger witnesses	1	0	3	4	0.06 (0.00-0.11)	
No witness recorded	19	0	11	30	0.41 (0.00-0.50)	
Other locations (Crossing, train)						
Driver and other rail staff	1	0	0	1	0.50 (0.00-0.50)	
No witness recorded	1	0	0	1	0.50 (0.00-0.5)	
Mental health						
Mental health issues (Depression, various non-specific issues)	24	4	17	45	0.17 (0.11-0.22)	There were relatively small proportions of incidents with mental health issues recorded. There is mixed evidence in the literature on the contribution of mental health issues [4], [13], [14], though mental health issues are thought to be a contributor to these types of events. The absence of this detail might be explained by gaps in knowledge or recording of this type of information in the database.
In-patients or out-patients at a psychiatric hospital	1	2	4	7	0.02 (0.01-0.06)	
Previous suicide attempts	0	2	4	6	0.02 (0-0.06)	

Not known	82	26	91	199	0.77 (0.76-0.78)	
Other social and health related						
Drugs / alcohol	2	0	1	3	0.01 (0.00-0.02)	There were very few records for these types of details in the available data sources. Evidence from the literature suggests that many of these factors are likely to be important contributory factors to these events [15], [16], [17], [18], [19], [20], [21], [22].
Family link to previous suicide	0	0	1	1	0.00 (0.00-0.01)	
Finance / loss of livelihood / homeless	0	1	1	2	0.01 (0.00-0.03)	
Legal / suspected of serious crime	1	0	3	4	0.02 (0.00-0.03)	
Multiple factors (e.g. finance, drugs alcohol)	1	0	0	1	0.00 (0.00-0.01)	
Other medical problems	0	0	2	2	0.01 0.00-0.02)	
Relationship problems	0	2	4	6	0.02 (0.00-0.06)	
Not known	103	31	104	238	0.93 (0.90-0.96)	
Gender						
Male	67	22	77	164	0.64 (0.62-0.66)	The higher proportion of males is consistent with findings from the literature [3], [4], [10], [11], though there is still a sizeable proportion of females involved in these types of incidents. The proportion of males increases to 0.76 (0.74-0.78) (female 0.24 (0.22-0.26)), based on the 218 cases where gender is known. There was no association between gender and study variables for location and timing of the event.
Female	19	7	27	53	0.21 (0.18-0.23)	
Not known	21	6	12	39	0.15 (0.10-0.20)	
Age **Numbers where age is known**	60	22	70	152	Mean 40.6 (39.8-41.6) SD 14.5 (13.4-15.9) Range 16-80	Age was recorded for many of those involved, but was often estimated or shown as a range in some cases in the SMIS data sheets, so limited data analyses are presented in this study. No age data was available in 105 events. There was an age related association, with higher than expected numbers of older people being involved in events on slower lines.
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Behaviour	Details of behaviour have been extracted from the narrative text in the database and presented later in this paper.					

Table 5 Extract showing fatality incidents on different lines in the vicinity of 6 consecutive stations, by year

										Year										
Pilot area 1	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Grand Total**
Station a														**1**			**2**				**3**
Down main																	1				1
Up Main														1							1
Other																	1				1
Starion b					**2**	**1**	**4**	**1**	**1**		**1**	**1**		**1**		**2**	**1**	**1**	**2**		**18**
Down main							1									1					2
Up Main					1	1	2	1	1			1		1		1	1	1	2		13
Up relief											1										1
Not known					1		1														2
Station c					**1**		**1**			**1**					**1**						**4**
Up Main					1					1											2
Down relief							1														1
Up relief															1						1
Station d							**1**				**1**		**1**							**2**	**5**
Down main							1				1										2
Up Main													1							1	2
Up relief																				1	1
Station e								**1**		**2**		**2**	**3**		**1**	**1**		**4**	**1**		**15**
Down main										1		1				1					3
Up Main								1		1			3		1			4	1		11
Not known												1									1
Station f						**1**						**1**		**1**		**1**			**4**		**8**
Down main																			4		4
Up Main												1		1		1					3
Other						1															1

Table 6a Sequences of behaviours and other descriptive content for events involving late movements in front of the train

Precursor behaviour	Immediate behaviour or action	Other descriptors prior to / during impact	Commentary / Interpretation
Movements Walked / ran to the edge of the platform (21) Moved from behind an object (6) Walked / ran along the platform (1) Danced to the edge of the platform (1) Stepped back temporarily (2) *Waiting behaviours* Stood close to the platform edge (13) Stood alone on the platform (3) Waited on the platform (1) Sat on a bench (1) Sat on the platform (1) Acting strangely, making rocking motions back and forth (1) *Looking / searching* Looked for the train (2) Looked at the train before jumping (1) Looked towards the driver (1)	**Jumped / stepped from the platform into the path of the train (86)**	Dived off the platform as if into a swimming pool (1) Dived in front of the train (1) Arms in the air / arms outstretched (1) Crouched down and rolled off the platform (1) *Other explanatory details* Driver sounded the horn (3) Several people on the platform (1) Seen at the station earlier in the day and taken home by police (1) Seen at the station earlier in the day (1) Pulled her coat up around her head before jumping (1)	These involved very late movement into the path of the train, with very little opportunity for others to intervene, especially where running to the platform edge or from behind an object. The precursor behaviours have been categorised and presented here as a list. It is possible to identify some short sequences of behaviours in the original data (e.g. moving from behind an object – walking / running to the edge of the platform), though these are not represented here for reasons of clarity in presentation of the findings. There are some behaviours that could increase the chance of detection (e.g. unusual behaviour such as sitting on the platform, unusual motions, standing close to the platform edge, looking for the train, being seen earlier at the station). However, it can be hard to separate these from other behaviours that are typical of passengers at stations. Sitting on a bench is not unusual, but with more detail, there may be something that would indicate a greater risk of incident. More descriptive detail is provided on how the person got onto the track or what they did just before impact for seven of the incidents. It is clear that several drivers were aware of a risk (sounding the horn).

Table 6b Sequences of behaviours and other descriptive content for events where the person is on the track for a period of time before impact with the train

Precursor behaviour	Immediate behaviour or action	Other descriptors prior to / during impact	Commentary / Interpretation
Movements Jumped / stepped from the platform onto the line (21) Jumped / stepped from a (different) platform onto the line (1) Walked ran to the edge of the platform (2) Moved from behind an object (2) Jumped / ran / walked out of the bushes onto the track (5) Walked down the embankment (1) Climbed over / through a lineside fence (1) Jumped / stepped onto the track (3) Walked / ran across the tracks (2) Walked / ran on the tracks (2) Walked / jumped in front of the train (2) *Waiting behaviours* Sat on the platform edge (1) Stood alone on the platform (1) Stood close to the platform edge (1)	**Stood on the track in the path of the train (41)**	Crouched down (1) Turned and faced the train (2) Facing the train (1) Looking towards the driver (2) Turned sideways (2) Turned to face away from the train (2) Arms in the air / arms outstretched (6) Covered ears (1) *Other explanatory details* Driver sounded the horn (5) Dressed in black (1) Limited sighting for the driver as the train came round a curve (1)	In this type of event the person is on a track for a period of time before the impact. In almost half of these, access was directly from the platform onto the line on which the train was travelling. The remaining incidents involved movement across tracks from another platform, from behind objects or entering the track from bushes or the lineside in locations outside of the station, before walking / jumping in front of the train from track level. Running across the tracks and running along the tracks are differentiated where it has been possible to do so. The records refer to warnings from the driver in a small number of cases, though this may not accurately reflect the number of warnings that would have been issued. Additional descriptive details are given for many of the events. It is possible that more detail has been provided in these cases because the driver had more time to see the event unfolding.
Movements Jumped / stepped from the platform onto the line (7) Jumped / stepped from a (different) platform onto the line (2) Moved from behind an object (1) Jumped / ran out of bushes on to the track (1) Walked / ran across the tracks Walked / ran on the tracks (2) *Looking / searching* Looked for the train (2)	**Walked / jumped in front of the train (18)**		These incidents involved a movement towards the train from track level, including moving along and across tracks. Initial access to the track was from a platform in half of the cases. There are relatively few precursor behaviours, though where present these give some details of looking for trains, moving from places of concealment, or how people accessed the track at a place other than a station.

Precursor behaviour	Immediate behaviour or action	Other descriptors prior to / during impact	Commentary / Interpretation
Movements Jumped / stepped from the platform onto the line (15) Walked / ran on the tracks (1) Jumped / stepped onto the track (1) Moved from behind an object (1) *Waiting behaviours* Knelt on the track (1) Speaking on a mobile phone (1) Stood close to the platform edge (2) Did not get on a stopping train (1)	**Laid down on the track in the path of the train (22)**	Lying face up looking upwards (1) *Other explanatory details* Driver sounded the horn (4) Covered the upper part of the body in a plastic sack (1)	In this group of incidents the immediate behaviour describes how the person took specific action to make contact with the train. More than half involved access from the platform. Few events seem to have involved crossing the track. The precursor behaviours are similar to other events. In most cases the access to the track was observed and is close in time to the approach of the train. There were four where the access to the track was not observed. Only one contained reports of efforts of the person to conceal themselves. Drivers reported issuing warnings in a small number of these events.
Movements Jumped / stepped from the platform onto the line (7) Jumped / stepped from a (different) platform onto the line (1) Walked / ran across the tracks (1) Walked / ran along the platform (1) *Waiting behaviours* Laid down on the track in the path of the train (3) *Looking / searching* Waved at the driver (1)	**Placed head on the rail in the path of the train (15)**		This series of events also includes description of the immediate behaviour of how the person made contact with the train. In one of the cases the person was seen stepping from a different platform and crossing the tracks.
Movements Jumped / stepped from the platform onto the line (6) Pushed past passengers (1) Jumped / stepped from a (different) platform onto the line (1) Walked / ran across the tracks (1) Walked / ran to the edge of the platform (1) *Other behaviours* Disembarked from a train (1)	**Crouched on the track in the path of the train (7)**	Curled into a ball (1) Appeared to be looking for something on the track (1) Bent down as if to pick something up (1)	In this subset of incidents the immediate behaviour describes what the person did after getting access directly from the platform or crossing tracks from another platform. Earlier behaviour included physical efforts to get to the track by pushing past passengers and moving directly from getting off a train to get onto the railway.
Movements Jumped / stepped from the platform onto the line (1)	**Knelt on the track (1)**		Limited details were available for these two examples of immediate behaviours before being struck by the train. In each case the person was seen to step onto the track from the platform, implying a short period of time before the arrival of the train. Some additional descriptive detail is provided in one case as the person awaited the train.
Movements Jumped / stepped from the platform onto the line (1)	**Sat on the track (1)**	Head lowered waiting for the impact (1)	

Table 6c Sequences of behaviours and other descriptive content for events where the person is moving around on the track prior to impact

Precursor behaviour	Immediate behaviour or action	Other descriptors prior to / during impact	Commentary / Interpretation
Movements Jumped / stepped from a different platform onto the line (3) Walked / ran along the platform (1)	**Walked / ran across the tracks (3)**	The driver lost sight of the person before impact (1) *Other explanatory details* Driver sounded the horn (1)	In these three subsets of incidents it is not clear from the content of the reports what happened after getting onto the line (i.e. whether the person stood on the track in the path of the train, laid down or moved towards the train, as in other chains of events). It is not clear from the reports how long the people were in the track area. There are reports of moving along and across tracks. The immediate behaviours in these sequences are precursor behaviours in a number of other incidents. In the first example there is one event where the driver reports losing sight of the person, but this is not explicit in the other events. In many cases access was from a platform. Drivers report issuing warnings in several of the events
Movements Jumped / stepped from a different platform onto the line (2) Walked / ran across the tracks (1) Jumped / stepped from the platform onto the line (1)	**Walked / ran on the tracks (2)**	Facing the train (1) Not facing the train (1) *Other explanatory details* Driver sounded the horn (2)	
Movements Walked ran to the edge of the platform (2) *Waiting behaviours* Stood close to the platform edge (2) Sat on a bench (1)	**Jumped / stepped from the platform onto the line (9)**	*Other explanatory details* Driver sounded the horn (1)	

Table 6d Sequences of behaviours and other descriptive content for events with other modes of contact with the train or other cause of death

Precursor behaviour	Immediate behaviour or action	Other descriptors prior / during impact or other cause of fatality	Commentary / Interpretation
Movements Jumped / fell from a bridge (3) Jumped / fell from a train or vehicle (1)	**On the track in the path of the train (4)**		This set of incidents contains details of a number of different types of immediate behaviours. These accounted for relatively small numbers in each case and there are few precursor behaviours for several of these. The first describes limited detail about how several people were on the track after jumping or falling from height at a bridge or from a train. The next three refer to unusual situations where people made contact with the train from the platform (leaning, sitting over the edge, overhanging the platform edge in a prone position). The immediate behaviours in the final three events are also quite rare (contact with overhead power lines after running on tracks and climbing a power gantry, hanging from a bridge and setting oneself on fire). Limited details are available in the data sources in relation to these events.
Waiting behaviours Stood close to the platform edge (1)	**Leaned forward into the path of the train (2)**		
	Sat on the platform with legs over the edge of the platform (2)		
	Laid down on the platform with head and shoulders overhanging into the path of the train (1)	Seen at the station earlier in the day and questioned by rail staff (1)	
Movements Climbed a power line gantry (1) Walked ran on the tracks (1)	**Contact with overhead electrical power lines (1)**		
	Hanging from a bridge (1)		
	Set on fire (1)		

Table 7 New guidance for improvement in the collection and use of data on a range of relevant variables for railway suicide

Variable	Summary of evidence	New guidance from the current study
National fatalities and Fatality rate	Fatalities, only, were considered in this study, which did not include national coverage of the rail system.	Local situations may not reflect nationally reported data (e.g. there can be larger proportions of events at stations than national statistics would suggest). Therefore, national patterns may not be helpful in understanding risk at a particular location. It is important to collect additional descriptive detail on events to explore the potential for better prevention strategies at a local level.
Age	There is a range of age groups thought to be at greater risk of these incidents on the basis of previous research in the literature, especially younger people and mid-age of 40-60.	People of all ages are involved in these incidents and prevention strategies need to take this into account. The age of people involved is not always evident in the early stage of compiling this type of record of events.
Gender	Previous studies show greater numbers of males involved in these incidents. There were similar findings in the samples in the current study.	Whilst more males die in these incidents, there is a still a sizeable proportion of females involved in these events.
Health status (including mental health and suicide threats / previous attempts)	Studies in the literature suggest the influence of mental health issues in rail suicide events. There are gaps in the data in the current study in relation to knowledge of mental health problems in the people involved.	Other sources of data are needed to explore the health status of individuals as a risk factor for rail suicide.
Timing - Seasonal, monthly, weekly variations	There are a range of conclusions in the literature on the timing of events (table 1). Analysis in this study has looked at timing in relation to the day, month, peak / off peak hours for travel and lighting conditions. It is clear that incidents can occur at all times of the day, week and year.	People are likely to be influenced in different ways, so it can be difficult to predict how any individual would respond on the basis of time of day, week or month alone. The choice of timing could be influenced by a range of factors (e.g. opportunity and the availability / frequency of trains; a desire for seclusion at night time or off-peak events). It will be important to understand more about why people choose different times to take their life on the railway.
Geography of railway suicides - Proximity of residence	Various studies in the literature have examined relationships between train suicides and geographical and rail contextual factors (linked to the location, train density, frequency). The current study, in its focus on descriptive detail in samples of events, has examined	It is important that industry / research records are able to reflect the range of locations that are important descriptors for an incident. Improvements can be made in collecting and recording important information on locations that are relevant for the event (e.g. precise

Variable	Summary of evidence	New guidance from the current study
- Clusters and hotspots - Proximity of mental health services - Population and railway traffic density - Location on railway property	some of the practical issues that can impact on the reliability of the data. Incidents do not always happen at the point of access to the railway (e.g. people often cross lines or move along the track and out of the station or away from crossings). The line on which an incident occurs does not always give an accurate indication of the train type and can lead to errors when classifying incidents in a national database (e.g. a fast, non-stopping train can be travelling on a slow line during a possession for engineering works). There is much anecdotal evidence to suggest that people select high speed trains for suicide. The limited data on train types in the database make it difficult to draw firm conclusions, but the available data suggest that a range of train types (faster and slower) are involved in these events. The design of the infrastructure might encourage certain behaviours (e.g. hiding behind electrical cabinets, bridges, in vegetation or at curves in the track, structures on the platform).	details of access points, the line of incident, the location of the incident, details of movement across or along lines). It is important that industry databases can record relevant details of anomalies in train operations and other local knowledge and circumstances, often known to local staff, and make this type of information available to users of the data. Prevention strategies therefore need to take account of the potential for events on faster and slower lines.
Behaviour immediately before suicide attempts	There is limited evidence from previous studies. The analysis of text in the current study provides a better understanding of the type and frequencies of different behaviours	Understanding more about the different sequences of behaviours of people prior to these events and the relative frequencies of these sequences gives better knowledge of where efforts could be targeted for prevention (e.g. knowing behaviours that could trigger suspicion in onlookers). A more extensive study of behaviours, using details from a wider range of sources, would help to develop these findings.