

Collecting evidence from distributed sources to evaluate railway suicide and trespass prevention measures

Brendan Ryan^{a*}, Veli-Pekka Kallberg^b, Helena Rådbo^c, Grigore M. Havârneanu^d, Anne Silla^b,
Karoline Lukaschek^e, Jean-Marie Burkhardt^f, Jean-Luc Bruyelle^g, El-Miloudi El-Kourssi^h, Eric
Beurskensⁱ, Maria Hedqvist^c

^a University of Nottingham, Faculty of Engineering, University Park, Nottingham NG7 2RD, United Kingdom.

^b VTT, Technical Research Centre of Finland Ltd, P.O. Box 1000, 02044 VTT, Finland.

^c Trafikverket, 78189 Borlänge, Sweden.

^d International Union of Railways (UIC), Security division, 16 rue Jean Rey, F-75015 Paris, France.

^e Institute of General Practice and Family Medicine, University Hospital of Ludwig-Maximilians-University Munich, Pettenkoferstr. 10, D-80336 Munich, Germany and Helmholtz Zentrum München, German Research Centre for Environmental Health, Institute of Epidemiology, Ingolstädter Landstr.1, 85764 Neuherberg, Germany.

^f IFSTTAR-LPC, 25, allée des Marronniers, Satory, 78000 Versailles, France.

^g University of Lille 3, France.

^h IFSTTAR-ESTAS, 20, rue Elisée Reclus, BP 70317, 59666 Villeneuve d'Ascq Cedex, France.

ⁱ Prorail, ProRail, De Inktpot, Moreelsepark 3, Utrecht, The Netherlands.

* Corresponding author brendan.ryan@nottingham.ac.uk

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Abstract. It can be difficult to select from available safety preventative measures, especially where there is limited evidence of effectiveness in different contexts. This paper describes application of a method to identify and evaluate wide-ranging preventative measures for rail suicide and trespass fatalities. Evidence from literature and industry sources was collated and reviewed in a two stage process to achieve consensus among experts on the likely effects of the measures and factors influencing their implementation. Multiple evaluation criteria were used to examine the measures from different perspectives. Fencing, awareness campaigns and different types of organisational initiatives were recommended for further testing. This is the first time evidence has been collected internationally across such a range of preventative measures. Commentary is provided on using this type of approach to select safety measures from a pool of prevention options, including how re-framing the scope of the exercise could identify alternative options for prevention.

Practitioner summary. The findings give insight to how different measures work in different ways and how industry can consider this in strategic initiatives. The method could be used in future studies with different frames of reference (e.g. different timescales, level of ambition and safety context e.g. railway crossings or highway fatalities).

Keywords: Rail fatalities; Suicide; Trespass; Prevention; Evaluation; Experts and consensus methods

1. Introduction

Close to 3000 railway suicides occur on European mainline railways each year. This represents about 72% of all railway fatalities and together with trespass related deaths, 89% of all fatalities occurring within the European railway system in 2012-2014 (European Union Agency for Railways 2016).

The railway industry is working to minimise the loss of life (e.g. see targets to reduce fatalities in Government Offices of Sweden 2016) and associated trauma to staff. This has needed a paradigm change and innovative thinking, taking account of individual, organisational and societal factors that can impact on these fatalities. There are many possible solutions. Some of the published work (e.g. Havârneanu et al. 2015) identifies and explains different types of preventative measures. However, the greatest challenge is in knowing what works and how, in the range of circumstances that are typical in international railways. The published evidence is not sufficient to provide the necessary guidance for the industry. This is not unusual within the published literature on evaluation studies in other areas of safety and ergonomics (e.g. Guastello 1993; Volinn 1999; Neumann et al. 1999; discussed in greater detail below).

The RESTRAIL project (<http://www.restrail.eu>) brought together seventeen major railway organisations, research institutes and universities from twelve countries, providing opportunities for gathering knowledge and wide-scale consultation on prevention measures. Whilst detailed testing of preferred preventative measures in different European contexts was a longer term goal, a preliminary phase of work was needed to identify the most appropriate measures that could be considered across Europe for prevention. This paper describes the application of a method that combines best practice from evaluation and consensus methodology to identify and evaluate wide ranging measures for prevention of railway suicides and trespassing incidents. Recommendations are made for preventative measures that should be examined in more detailed field studies.

2. Background

2.1 Existing evaluation studies for rail suicide and trespass

Many different preventative measures have been implemented internationally, with the intention of reducing the frequencies of fatalities. Review publications (e.g. Botha et al. 2014; Gabree et al. 2014) contain references to different prevention strategies, such as fencing, redesign of lighting, media guidelines, education and warnings to people, use of patrols or prohibitive signs. Whilst these contain explanatory details of these prevention measures there are limited published details on the potential effectiveness of the measures.

Havârneanu et al. (2015) carried out a systematic review of evidence in the literature in parallel with this current evaluation study. Nineteen measures were identified (shown later in Table 6), ordered by frequency of citations across twenty two publications that considered the effectiveness of

suicide and trespass measures. Whilst the evidence is building, there are still limited numbers of good studies of safety interventions in the railway environment.

There are many reasons why it is difficult to study the effectiveness of these types of rail safety interventions. Firstly, it can be hard to transfer findings from one country to another (Elvik 2012), because of specific cultural and sociological phenomena. Havârneanu et al's (2015) review revealed that most of the existing evaluation results come from single studies from one country or limited contexts. Only physical barriers (Law et al. 2009, Beautrais et al. 2009, Lobb et al. 2001 and Silla and Luoma 2011) and media guidelines (Hegerl et al. 2013 and Etzersdorfer and Sonneck 1998) had sufficient evidence from multiple studies in a variety of cultural contexts. Extraneous factors (e.g. socio-economic factors), can influence the numbers of suicides in a location (Too et al, 2014, 2015), though it has been difficult to demonstrate such effects in recent studies (Uittenbogaard and Ceccato 2015). There are also important differences in how prevention measures may function in suicide and trespass events. Media guidelines, for example, are implemented specifically for suicide, to ensure responsible reporting about incidents and to avoid copycat effects (Hegerl et al. 2012). Similarly, trained staff at stations (Isaac et al. 2009) can help people who contemplate suicide. Warning signs (Lobb et al. 2001) are more appropriate for prevention of trespass. Barriers (e.g. Law et al. 2009) can protect against suicide and trespass. However, there are situations where a safety measure can reduce incidents in one situation but increase incidents in another. For example, a verbal warning of the approach of a fast, non-stopping train could reduce the numbers of accidental events at a station, but increase awareness of an approaching train for suicidal people. It is therefore important to understand the different motivations of people and how these might influence the likely success of preventative measures. Useful process models have also been developed to describe how preventative measures can be applied at different points in the period before an event (Rådbo et al. 2008; Burkhardt et al. 2014). These models classify preventative measures by five different mechanisms: measures that focus on influencing the perceived attractiveness and availability of rail traffic as a means of suicide, measures influencing access to tracks, early warning measures to enable a fast response to threats, measures to persuade people to leave a place of danger and measures to minimise the consequences of collision.

2.2 Previous safety evaluation studies

Many existing evaluation studies consider one or a small number of safety measures in a given context. Neumann et al. (2010) have suggested that evaluation studies need to move beyond the traditional experimental approaches (e.g. randomised control trials) that are highly regarded in the scientific literature. Review of guidance from the safety literature (Shannon et al. 1999; Baril-Gingras et al. 2006), including those advocating realistic evaluation approaches (Nilsen 2007; Pawson et al. 2005; Pederson et al. 2012) emphasise the need for the following components in evaluation studies: clear statements of study objectives; focus on the concept or theory behind the safety measures;

explicit descriptions of the safety measure, the context in which it is implemented and the participants; and specification of a variety of potential outcome indicators. In the current study, decision makers need to be able to select from a range of possible safety measures. It is necessary to distinguish strong research from other less well-designed work (Elvik 2008, 2012), in the process of identifying the interventions with the greatest potential for future application. However, evaluation can be difficult where there is a paucity of detail on both the implementation and outcomes from the interventions within the published evidence (Guastello 1993; Volinn 1999). An example of the type of study that is needed is described in Siegrist (2010), assessing national road safety programme measures, to prioritise those with the potential to save the greatest numbers of lives. Siegrist's method highlights the importance of clearly identifying the types of accidents that are impacted by a measure, also describing a process of calculating maximum and average reductions in fatalities. This considers the target number of incidents that could be influenced by the preventative measure, the proportion of the incidents that the measure can be applied to, the proportion that can be prevented with implementation and the extent of implementation of the measure. Siegrist is aware of limitations in available data relating to interventions and recommends being explicit about the data sources and estimates that are used, as well as presenting forecasts for decision makers as a range.

Elvik and colleagues (Elvik 2012; SUPREME 2007) embarked on a similar task, aiming to select the best road safety measures from options across Europe. The SUPREME method used country based experts to gather information from European stakeholders. Safety measures were classified, selected and ranked, in order to identify those that could bring about a sustained reduction in fatalities. Their method was built around the use of eight selection criteria (shown later in Table 1).

2.3 Applying appropriate methods to evaluate wide ranging preventative measures

Where there is limited scientific evidence or where the evidence is contradictory, experts are often consulted (Fink et al. 1984; Morgan and Mansfield 2014; Piccoli 2003). It is necessary to consider how consensus is achieved where members of an expert group are interpreting evidence from disparate sources. Several consensus methods are available, including nominal group, Delphi and consensus panel methods (Fink et al. 1984; Keeney et al. 2011; Murphy et al. 1998; Waggoner et al. 2016). None of these methods in their pure forms were appropriate for the types of ratings, validation and discussions that were needed to gather the additional evidence for the current study. However, the underlying principles and typical steps in consensus studies (Fink et al. 1984; Murphy et al. 1998) were considered. These included ensuring clarity and relevance of the task or question to be addressed, appropriate selection of participants, choosing and preparing the scientific evidence, structuring the interaction between participants, and having effective methods for collecting and synthesising individual judgements.

In conclusion, it was clear that the evidence on rail suicide and trespass prevention was scarce and difficult to access, with relevant knowledge and practical experience widely distributed across individuals, organisations and countries. Furthermore, there was no existing shared framework or pre-established criteria for evaluation of suicide and trespass prevention measures. This indicated that both the content and the evaluation method should be elaborated and agreed on between expert participants. The constituent parts for this method are available, drawing upon the following: the existing methodology for evaluation of safety interventions (Shannon et al. 1998; Baril-Gingras et al. 2006), best practice for reaching consensus (Fink et al. 1984; Murphy et al. 1998; Waggoner et al. 2016) and the practically based evaluation criteria that have been used in road safety studies (Siegrist 2010; SUPREME 2007).

3. Method

The main features of the evaluation method are illustrated in Figure 1 and explained below.

[Figure 1 about here]

3.1 Clarifying the tasks and questions to be addressed

The study had a number of purposes (i) identifying and collating evidence on known preventative measures and (ii) identifying the most promising measures for prevention that are candidates for testing in future field trials. These were achieved using qualitative and quantitative data from literature and expert input in a two stage consultation process.

3.2 Selecting appropriate participants and allocating roles

All participants were members of the RESTRAIL consortium or nominated by consortium members, working in positions where they had specialist knowledge of research or practice in the prevention of rail suicide and trespass. This included industry staff who have the power to implement solutions and can provide essential contributions to this type of expert group (Fink et al. 1984).

Two researchers worked on developing the process and refining evaluation criteria for use in the study. A core group of ten (Figure 1 for details) took part in a series of tasks to collect details of all known preventative measures and collate evidence about the implementation and effectiveness of these measures, section 3.3). Twenty two participants (the core group, plus an additional twelve participants) participated in the second stage of the evaluation, reviewing and discussing evidence and ratings on the implementation and effectiveness of each type of measure (Section 3.4). The members of the core group analysed the data, after the larger group consultation (Section 3.5).

3.3 Preparing appropriate scientific evidence

This was carried out by the core group and involved two main activities, as explained below.

3.3.1 Identification and preliminary classification of known preventative measures

Working within the RESTRAIL consortium offered good opportunities to collect details of known preventative measures across Europe. This included search for content in literature and industry documentation, as well as collecting additional knowledge from industry staff. A questionnaire was sent to all project partners, asking about which preventative measures have been implemented, whether the effectiveness of these measures had been evaluated and details of new measures that could be used (Silla et al. 2012). Responses were collated and screened by the core group, using a card sorting exercise to remove duplications. A list of 90 preventative measures was produced and these were grouped into 38 “types of measures”. A type of measure included several measures that share common contexts or effect mechanisms, for example grouping together different fencing interventions. A full list of these types is provided later in Section 4.

3.3.2 Collation of evidence on types of preventative measures

A form was created to collate practical and empirical evidence from a number of different perspectives about the implementation and effectiveness of each type of preventative measure. The structure of this form was inspired by the content considered by Siegrist (2010) (e.g. target number of incidents, proportion of events that can be prevented) and the evaluation criteria from Elvik and colleagues (SUPREME 2007). Elvik’s evaluation criteria were supplemented by incorporating elements from RAMSHEC (Reliability, Availability, Maintainability, Safety, Health, Environment and Costs, Jovanovic and Zoeteman 2010) for a better fit to this railway context. Fourteen evaluation criteria were produced, as listed in Table 1.

[Table 1 about here]

Evidence was collected from existing publications or other industry sources in a series of iterative steps by members of the core group. Each core group member was assigned a subset of the preventative measures (from Section 3.3.1) and they added evidence or commentary to a form for each of the measures. Completed forms were then returned to the coordinating researcher and any questions arising from the exercise were discussed in a group teleconference. The forms were then re-allocated to another member of the core group for review and addition of supplementary evidence. There was a minimum of four rounds of review (up to a maximum of six rounds) for the content of forms for each type of measure. This was the first stage in building consensus on the evidence amongst members of the core group.

The set of evaluation criteria was also used to produce four different types of ratings, as detailed below.

3.3.2.1 Safety effect score

The annual reduction in fatalities following implementation of the different measures was estimated using criterion 4 (Table 1), giving a preliminary indication of the effectiveness of measures. The effects were estimated at a European Union (EU) level by a researcher from the core group, taking the annual numbers of railway suicides and trespassing accidents in EU countries as a starting point (2,854 suicides and 782 trespassing fatalities, using data from the European Railway Agency Database of Interoperability and Safety – ERADIS database, and the International Union of Railways - UIC safety database of incidents, Silla et al. 2012,). This estimate considered the following factors:

- the size of the target group – this could be influenced by the location of the incidents, the context in which the measure is implemented (such as lighting conditions in daytime or night time) or the type of target groups of people;
- the expected level of implementation – this was the assumed proportion of target incidents it was considered possible and realistic to cover by the measure, within a reasonable time period;
- the expected percentage reduction in target incidents – this was estimated and later discussed and adjusted by consensus of the wider group of experts (section 3.4), including consideration of the numbers of incidents occurring in different contexts.

A spreadsheet (Excel) based calculator tool was used to calculate and record these estimates.

3.3.2.2 Total Qualitative Score

Ratings were produced for each of the types of preventative measures on nine of the remaining evaluation criteria (criteria 5 to 13). To produce these, one of the core group members (from an infrastructure management organisation) completed a scoring exercise, assigning values of 2, 1, 0, for each of the criteria (2 where no problems were foreseen in implementation of the measure with respect to the criteria in question; 1 where minor problems were anticipated; 0 where major problems were anticipated). Explanations of the rationale for the ratings were recorded in a document (e.g. why a particular measure may be rated lower on criteria such as cost or the impact on railway operations). As an example, the criteria for the durability of the effect for the measure of Fences was scored 2 for suicide and 1 for trespass, because it was felt that trespassers would be more willing to climb fences than people who were attempting suicide. The ratings were recorded in a matrix for each type of measure, as assessed against the nine evaluation criteria.

3.3.2.3 Implementation score

As part of the analysis of these ratings (from 3.3.2.2), the matrix of scores was reviewed to identify any “zero scores” on criteria for each of the measures. A zero rating on one criterion or more means that there are likely to be major problems in implementing the measure. Zero scores were highlighted in the matrix.

3.3.2.4 Survey Score

A small survey of project partners and their contacts was carried out in nine countries across Europe (UK, Spain, The Netherlands, Sweden, Israel, Turkey, France, Germany, Switzerland), to collect ratings of their preferences for different types of preventative measures. Industry stakeholders in each of these countries received a list of the thirty eight types of measures and ranked their top five preventative measures from the list. Responses were used to produce the Survey Score, providing an initial indication of the numbers of countries in which each type of measure was thought to be effective.

3.4 Reviewing and achieving consensus on evidence, estimates and ratings for the different types of measures

The second stage of achieving consensus on the evidence involved a meeting with the wider group of experts (22 people), to validate the available evidence and to collect new perspectives on implementation of the measures (e.g. knowledge from the industry or other details of evaluation studies or data).

3.4.1 Preparing for the expert meeting

The approach to managing discussions and developing consensus was considered prior to the meeting. Firstly, important roles were allocated. The facilitator took on roles of planning and controlling the sequence of tasks for the meeting, so that consensus on evidence for each preventative measure could be achieved in the time available. The Secretary, like the HAZOP secretary (Kletz 1986; Kirwan and Ainsworth 1992), took on the role of summarising the content of discussions and recording the rationale for decisions. One participant planned to present the preliminary estimates and collect the supporting rationale for the likely effects of the preventative measures (Section 3.3.2.1). Another presented the simple ratings and supporting rationale for ratings on factors affecting implementation of each preventative measure (Section 3.3.2.2 and 3.3.2.3). A judge or adjudicator was identified, if an agreement could not be reached.

Rules for agreement on the evidence were established. Opinions of people from different backgrounds were valued (e.g. the opinion of a rail infrastructure manager could give a different insight to someone from a research background). A majority decision was not necessarily essential, reflecting that there can be strong national perspectives in this study with worldwide application and compelling arguments could overcome an initial majority view. It was not necessary to demonstrate

conclusive evidence that a measure would be effective, as promising measures could be trialled in different locations in later phases of the programme of work. In practice, this was a transparent process with a clear structure and there were no major disagreements that could not be resolved at the meeting.

A shorter set of reference material was created by summarising content from the multiple rounds of collating and reviewing the evidence by the core group. This reference material contained a clear description of each of the preventative measures, relevant descriptive content for each of the evaluation criteria, preliminary ratings on factors influencing implementation and estimates for the size of the problem, explained in section 3.3.2. The reference material was given to the group prior to the meeting.

3.4.2 Procedures during the expert group meeting

This meeting was carried out over one and a half days. The participants reviewed the content of the condensed version of the evidence, to validate the main conclusions from the collation of evidence. The four types of scores (Section 3.3.2) were used in discussion of the evidence and these were projected onto a screen so that they were visible to all participants during discussions for each type of measure. Displaying these meant that they could be adjusted with agreement of all participants.

To emphasise the uncertainty of the estimates for the Safety Effect Score (Section 3.3.2.1, i.e. the calculated potential reduction in the numbers of EU level fatalities), lower and upper values of the estimated effect were defined by consensus. Adjustments were also made for the Total Qualitative Score (sum of scores across a range of criteria, section 3.3.2.2). It was agreed at the meeting that a weighting of two should be assigned to the ratings for four of the criteria, so that greater emphasis was given to these over others. This weighting gave preferences to identifying measures that are likely to be durable, have a favourable cost-benefit ratio, have a low impact on railway operations and have the potential to transfer to other countries. Agreed scores were recorded in a table to enable comparisons across the types of measures.

3.5 Analysing, synthesising and interpreting data on preventative measures, to provide recommendations for testing

Judgements on the future use of the preventative measures were clarified in analyses after the expert meeting, using a combination of the four sources of data.

The primary goal of the evaluation was to choose RECOMMENDED and PROMISING measures from among those that were evaluated. In order to become RECOMMENDED the measure had to: exceed the threshold value (see later in Section 4) in all four data types: Safety Effect Score, Total Qualitative Score, Implementation Score and Survey Score.

The measures that did not qualify for the RECOMMENDED category were assigned to the PROMISING category if they exceed the threshold value in three out of four of the above mentioned

data types, or exceed the threshold in two of the data types and perform well in comparison with other preventative measures with respect to the remaining data types.

4. Results

The evaluation results are summarised in Table 2.

[Table 2 about here]

Threshold values were identified for each type of data. These threshold values indicated the score or rating, above which a measure was assumed to score highly in comparison to others in the evaluation exercise.

4.1 Safety effect score

The estimated effect (i.e. estimated reductions in the numbers of fatalities across Europe) on the annual number of fatalities varied from 0 to 128 for measures targeted to prevent suicides and from 0 to 44 for measures against trespassing. This calculation used estimates of the likely percentage reduction in fatalities. As an example, an estimate of 0 to 5% reduction in fatalities was assumed for mass media campaigns, in comparison with 50–80% reduction for fencing at stations. This implies a greater success rate for fencing, but the calculation also considered that fencing would be likely to be applied at a smaller number of locations, in comparison with the potential reach of the media campaigns. Therefore, the final estimated reductions of suicide related fatalities were ranges of 21 to 207 and 74 to 118 for mass media campaigns and fencing at stations, respectively (Table 2).

In order to pass the threshold value for Safety Effect score, it was agreed by the expert group that the estimated annual reduction of fatalities should be over ten. Twenty three measures for the prevention of suicides and ten for the prevention of trespass passed the threshold value (marked “1” in the respective column of Table 2).

4.2 Total qualitative score

The results for Total Qualitative Score are shown also in Table 2. Ratings on each of the nine criteria for this score are presented in Table 3. The Total Qualitative Scores varied from 9 to 25 (with a maximum possible score of 26). A Total Qualitative Score of 21 was selected as the threshold value. Seventeen measures for the prevention of suicides and fourteen measures against trespass passed the threshold value.

[Table 3 about here]

The table can be inspected to identify low scores on various criteria. For example, there were low scores on many criteria for the two train design solutions to reduce the impact of collisions. The airbag solution was rated lower than the redesign of the front of the trains.

4.3 Implementation score

Potential implementation problems are indicated by the Implementation Score (i.e. zero scores in Table 3). The threshold value was that none of the nine criteria were rated as zero. Twenty two measures dedicated to the prevention of suicides and nineteen measures against trespass passed the threshold value for Implementation score. Inspection of “zero ratings” for the train design solutions shows that there were serious concerns around cost-benefit and technological issues with those solutions.

4.4 Survey score

Measures that were recommended by at least three of the railway professionals from seven countries were labelled as the strongest measures on this data type. This represented the upper quartile of the types of measures for suicide prevention and the top 40% of the measures for trespass prevention. Ten measures for the prevention of suicides and ten measures for the prevention of trespass passed this threshold criterion.

4.5 Combining the results from the four scores

Having regard to these thresholds for the scores on the four data types, sixteen measures were labelled as RECOMMENDED or PROMISING for the prevention of suicides, as indicated in Table 2. For the prevention of trespassing, ten measures were labelled as RECOMMENDED or PROMISING. Seven measures were labelled as RECOMMENDED or PROMISING for the prevention of both suicide and trespass. The results have been compared with evidence from the literature (also shown in Table 4) and are discussed in more detail in section 5 below.

[Table 4 about here]

4.6 Descriptive comments from the discussion at the expert group workshop

The contents of discussions of the rationale for ratings and estimates were recorded in a text format. Table 5 includes examples of a selection of comments, covering issues that could affect the implementation and likely success of the preventative measures. New measures were also identified during these discussions and further details of the implementation of these measures were considered. Occasionally, participants acknowledged problems in applying parts of the evaluation method.

[Table 5 about here]

4.7 Commentary on the findings from the evaluation exercise

Nineteen of the 38 types of measures were either recommended or promising for the prevention of suicide or trespass (Table 4). There has generally been agreement between the findings from the evaluation process and the available literature (some of which have been published after this evaluation exercise) on the different types of measures (Table 4). The results from further classification of the measures are presented in Tables 6 and 7, to help with understanding of features of the preventative measures.

Table 6 examines how the preventative measures can be grouped according to similar types of measures (e.g. awareness / education, physical measures to restrict access, see also Table 4). The table shows the relative preferences for measures in these groupings and any differences in how these were evaluated in the literature based study by Havârneanu et al. (2015). Campaigns or provision of information in educational / awareness type initiatives were the most common measures that were selected, followed by organisational initiatives, physical measures, environmental design and surveillance. Of the nineteen types of measures that were not found to be recommended or promising, more than half of these involved surveillance, environmental design or organisational initiatives (Table 6). The less favoured measures were linked to train design, support for drivers, slowing down traffic or attempting to dissuade selection of the railway for suicide.

The classification from Rådbo et al. (2008) has been used to explore how the selected and less favoured preventative measures will exert their effects in practice, as shown in Table 7. The preventative measures are likely to work in different ways, often employing several of the underlying mechanisms of effect. Even where there is a clear main effect (e.g. fencing can inhibit access to the railway), a well-fenced station might also reduce the attractiveness of a station as a place of suicide or enable an early warning if someone is in a place that they should not be. Influencing the attractiveness of the railway as a place for railway suicide was the most common mechanism of effect for the selected measures.

[Table 6 and 7 about here]

5. Discussion

5.1. Findings from this evaluation

This evaluation study has brought together evidence on a wide range of practical prevention measures and provided a forum to explore the factors and circumstances that can impact on the implementation and success of these safety interventions. The evaluation process has been successful in its aim of discriminating between the different measures, identifying a shorter list of those that are recommended or promising for prevention of rail suicide and trespass (Tables 4, 6). There are several

ways in which the preventative measures can be classified. However, a workable set of types of measures was identified and grouping the measures was a valuable part of a first stage assessment that produced the preferred prevention strategies. Classifying the measures by their underlying mechanism of effect (Rådbo et al. 2008) demonstrates how the preferred measures work in different and often multiple ways. These are plausible mechanisms, but there is little information from existing field studies to clarify precisely how these work. The classification in this study enables researchers and industry staff to think about what they are trying to achieve and how they are doing this through application of different types of measures. It is worth questioning whether the right complement of measures is used and whether it is really understood how measures that are implemented are working, either alone or in combination.

It is interesting to see the relative preferences arising for awareness / educational approaches, which commonly aim to influence the attractiveness of the railway for suicide. Organisational initiatives such as risk assessment or fencing to restrict access to the railway were also selected (Table 6, 7). There is currently limited compelling published evidence (Table 4) on the effectiveness of measures such as campaigns or risk assessment in the rail context, though there is strong support for the use of fencing (e.g. Cox et al. 2013; Law et al. 2009).

Lower overall ratings have been produced for several of the types of measures: various surveillance approaches that might provide early warning of risk; the design and reconfiguration of the railway environment; interventions to redesign trains or the infrastructure to reduce the impact of collisions; and attempts to support the driver through technology or training to reduce the likelihood of an event. These may be viable options for prevention, offering longer term benefits, but currently need more development. For example, many surveillance technologies are being developed (see the review in Ryan 2018). More extensive studies might be needed to explore solutions related to environmental design, such as novel lighting installations or better station layouts. These would not have been possible in the timeframe of a project such as RESTRAIL and therefore did not perform well in the current assessment exercise.

Gatekeeper training is another interesting absence from the measures that have been favoured in this evaluation. This measure incorporates aspects of surveillance and applies strategies to encourage trained staff to approach someone to prevent an incident. It receives support in the literature (Lukaschek et al. 2013; Cross et al. 2010; Isaac et al. 2009) and is being used at present in the industry (e.g. Great Britain, RSSB 2013).

Whilst collecting evidence from the expert group, there have been very few examples of preventative measures that were new or previously unknown. This is perhaps not surprising, as the experts were reporting on what is generally known and used within the industry. In the future, new prevention measures may emerge by considering how the more promising types of preventative measures could be adapted to respond to the known challenges for prevention of railway suicide and

trespass. It is likely that expert judgement in this study has been influenced by the framing of the problem. Outcomes have been conservative with good reason in this study, which was identifying preventative measures that could be tested in a short period of time. More ambition and novelty in the selection of measures could be achieved by applying the method of evaluation using different terms of reference and instructions to participants about the likely timescales and risks for implementation of the preventative measures.

5.2 Application of the method of evaluation in real world contexts

There are many different ways to evaluate preventative measures for suicide and trespass on the railway. This can be achieved by looking at individual measures (e.g. in field studies such as Ueda et al. 2015), but the large numbers of options collected in the opening parts of this study indicated that this would not be feasible. The current research has applied a method to investigate and compare many potential safety interventions, covering both the implementation of the measure and likely outcomes of the measure (Nilsen 2007; Pawson et al. 2005; Pederson et al. 2012). There are many common features of methods that are used for the prevention of deliberate or accidental events. Similar evaluation processes were used to study suicide and trespass interventions, whilst bearing in mind differences in the context and behaviours of those involved.

This type of evaluation of multiple preventative measures for railway fatalities has not been attempted previously and there have been no similar studies to collate the necessary evidence. The evaluation process and mutual learning involving both research and field experts in this study has therefore created the evidence where it has been lacking, because of the absence or the quality of studies (Elvik 2012) in this rail context. This has included review of studies on similar interventions, such as fencing at bridges (Law et al. 2014), to determine the way in which a measure works and its likely effect in a set of anticipated circumstances. The evaluation method that has been applied is not new, but combines known methods in a novel way to investigate a special issue that poses challenging problems for rail administrations. An extensive body of evidence has been produced about these preventative measures, providing a useful resource and guidance for the industry (<http://www.restrail.eu/toolbox/>; Wisniewski and Havârneanu 2016).

There are some limitations in the evaluation method that has been applied. Firstly, there is a lack of evidence on which to base ratings, estimates and conclusions during the review process. This was of course the reason for convening the groups of experts. It is recognised that expert opinion can be classified as lower than several others on a hierarchy of evidence (Foth et al. 2016) and that in the use of consensus methods there is no right answer, just consensus on the available evidence (Fink et al. 1984; Keeney et al. 2011). Evidence from consensus of experts was needed to fill gaps in knowledge in the current study and led to a pragmatic conclusion (Volinn 1999).

It is accepted that there is imprecision in the estimates and ratings, and there could be bias according to what is familiar to the expert participants in their own organisations, fields of research or countries. There are potential weaknesses in use of any one of the data types on their own. For

example, the stakeholder survey was small, only a very simple rating system was used with each of the criteria, and various approximations and assumptions are needed in determining estimates of effect. To counteract this, results from the various data types are synthesised to produce the final recommendations. Combining the types of data allowed comparison of the different preventative measures across multiple attributes and corroboration of the evidence. This gave greater confidence in the selection of the best measures for more detailed testing in future work. The results from this exercise also established the reasoning for why these are preferred (e.g. because of no problems with implementation, assessed across a range of criteria). It is possible to see through inspection of the ratings where preventative measures are likely to be strong or weak and the levels of improvement in safety that could be achieved.

Another limitation is the potential for bias in the interaction between group members, with a tendency towards agreement or undue influence of some members of the group. This could have been countered by collecting separate ratings (e.g. using a Delphi technique). However, this study was about learning as well as consensus and a method was needed that encouraged discussion between the experts that were available. Steps were taken during the facilitation of the group consultations to ensure full visibility of the findings and encourage contributions. This included requests for new evidence or alternative viewpoints, recording the rationale used in decision making and adjusting estimates for effect size based on knowledge of different local conditions.

Finally, this evaluation study, as is the case in previous research activities (van der Feltz-Cornelis et al. 2011; Gabree et al. 2014), has largely considered the evaluation of single measures. This has been necessary as a first step in understanding the mechanisms of prevention. Testimony from rail organisations taking part has suggested that it is important to consider the application of many of the preventative measures in combination, because there may be synergy between different interventions as they counteract different risk factors on multiple levels (Guo and Harstall 2004). However, knowledge of how to combine different measures in an effective suicide or trespass prevention strategy is lacking (Mann et al. 2005). More in-depth evaluation of a collection of measures, in specific contexts (e.g. at stations, crossings or other locations), will need to be considered in field tests.

6. Conclusions

There is currently limited evidence on what types of safety prevention measures for rail suicide and trespass are effective (i.e. what works and in what circumstances). A method has been applied to collect new data to evaluate safety measures to prevent rail suicide and trespass fatalities. This has been based on existing best practice for evaluation and consensus studies, collecting and reviewing descriptive content, ratings on factors affecting implementation and estimates of the success of the preventative measures. This is the first time evidence has been collected by an international group of experts across such a large range of preventative measures. This type of evaluation can be

applied at an early stage of a project to select from amongst a broad set of options. The study achieved its goal of identifying a shorter list of preventative measures that are appropriate for further testing in field studies. These included fencing, awareness campaigns, and organisational initiatives. The analysis gives insight to how different measures work in different ways and how the industry can consider this in strategic initiatives. The findings contribute to the evidence base in this area and can be used in setting the agenda for future exploratory studies for new interventions and especially combinations of interventions.

There were mixed findings about the value of some of the prevention measures, such as surveillance or design related interventions. Re-framing of the scope of the assessment might produce different results. Experience of use of the evaluation method indicates that it could feasibly be adapted and used in evaluating safety interventions in other contexts, such as to understand and select measures in more ambitious prevention programmes, with longer implementation periods and with other safety problems (e.g. collisions at railway crossings, suicide prevention measures on highways). More evidence is appearing within the literature on known and emerging interventions on rail suicide and trespass and the evaluation exercise can be reviewed and re-applied to take account of new knowledge.

[6565 words]

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List of Figures

Figure 1 Features of the evaluation method

List of Tables

Table 1 Criteria for the evaluation

Table 2 Summary of the evaluation results

Table 3 Scores given to different qualitative evaluation criteria

Table 4 Recommended and promising measures for the prevention of railway suicides and trespassing, including comparison of evidence from the literature

Table 5 Examples of commentary on the implementation and likely success of different measures

Table 6 Selection of different types of preventative measures for suicide and trespass from applying the evaluation methodology

Table 7 Classification of selected and non-selected preventative measures by different mechanisms of effect (extended from Rådbo et al. 2008)

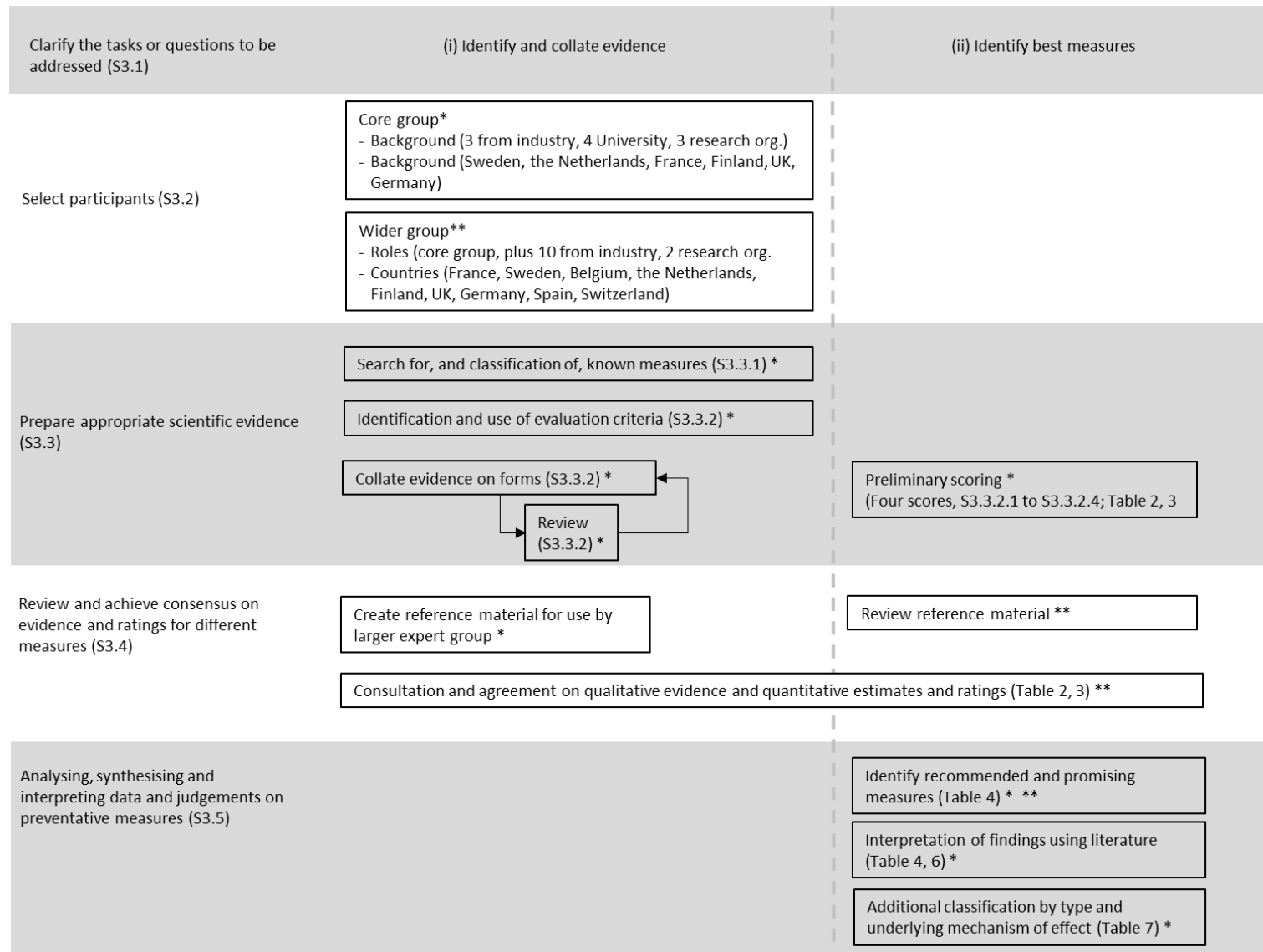


Figure 1 Features of the evaluation method

Criteria	Characteristics
*1. Description of relevant features of the measure.	Description / qualitative detail on the safety measure and context
*2. Definition of target incidents - whether the measure is intended to reduce certain types of incidents or focus on a specific group of people (such as children)	
*3. Size of the problem - a quantitative estimate of the frequency of target incidents (e.g. trespassing accidents in the target group per year).	
*14. Effect on incidents - the expected effect of the measure on target incidents, based on evidence from field studies or estimates by experts.	Assessment of effect of the safety measure Additional rail related and other criteria that influence the implementation and effectiveness of the safety measure
*5. Durability of effects – whether the effects of the measure are likely to be permanent or erode with time.	
*6. Costs and benefits - approximate estimates of the costs and benefits, if available, or determination of the likely cost – benefit ratio.	
7. Integration with other policy measures – whether the measure will work well alongside other preventative measures or interventions.	
8. Impact on railway operations – whether there are likely to be positive or negative effects on the train service.	
9. Impact on people and jobs in the railway industry – whether implementing the measure may increase or decrease risks to health and job opportunities within the railway industry.	
10. Technological issues – whether there is need for changes in the existing technology and infrastructure, also considering the level of readiness of technology for effective implementation of the new safety measure.	
11. Environmental issues – whether there are likely to be impacts on the environment from introducing the measure (e.g. pollution, impacts on scenery and wildlife).	
*12. Acceptance – whether the measure will be accepted by the public and relevant stakeholders (e.g. policy makers, industry).	
*13. Transferability – how the measure can be transferred and applied in different railway contexts.	
14. Additional information - any relevant information that is not dealt with in the criteria listed above. This will include assessment of the strengths, weaknesses, opportunities and threats associated with the measure.	

*Based on the original criteria used by Elvik (SUPREME, 2007, Elvik, 2012)

¹ Expected effects and Actual impacts were used in the earlier work by Elvik

Table 1 Criteria for the evaluation

ID	Types of measures	Total qualitative evaluation criteria score		Assumed number of fatalities in target group		Effect on targeted fatalities % reduction – presented as a range.				Estimated reduction in the annual number of fatalities				Categorisation criteria ("1" indicates passing of threshold value)						Classification R = recommended P = promising			
						Suicides		Trespass		Suicides		Trespass		Scores for Suicides			Scores for Trespass						
		Suicides	Trespass	Suicides	Trespass	Min	Max	Min	Max	Min	Max	Min	Max	Total qual.	Safety effect	Implement.	Survey	Total qual.	Safety effect	Implement.	Survey	Suicides	Trespass
1	Alternative to railway suicide e.g. making people aware of other choices of methods of suicide, but this measure received little consideration for ethical reasons	20	0	357	0	0.02	0.10			7	36	0	0	0	1	0	0	0	0	0			
2	Light to increase visibility at hotspots e.g. Lighting at identified hotspots such as crossings, tunnels and bridges	23	19	114	31	0.02	0.15	0.02	0.10	2	17	1	3	1	1	1	0	0	0	0	P		
3	Temporary speed reduction or traffic shut-down when a risk is detected e.g. stopping or slowing down trains when there is a report of someone on the line	14	14	143	39	0.01	0.05	0.01	0.05	1	7	0	2	0	0	0	0	0	0	0			
4	Landscaping e.g. Removal of vegetation to increase visibility	23	23	528	51	0.02	0.10	0.01	0.05	11	53	1	3	1	1	1	0	1	0	1	0	P	
5	Surveillance technologies to identify and prevent incidents e.g. using CCTV cameras, fake CCTV camera boxes or infrared cameras	18	16	285	78	0.00	0.02	0.00	0.01	0	6	0	1	0	0	0	1	0	0	0	1		
6	Lighting devices to influence behaviour e.g. Dispelling light source, lighting linked to movement sensor	23	20	42	10	0.05	0.30	0.10	0.40	2	13	1	4	1	1	1	1	0	0	0	1	R	
7	Detection and surveillance systems e.g. Intelligent CCTV combined with sound warnings	24	19	106	25	0.03	0.15	0.02	0.10	3	16	1	3	1	1	1	1	0	0	1	1	R	
8	Patrols and enforcement e.g. Security patrols, security patrols able to fine	17	17	428	117	0.05	0.30	0.10	0.40	21	128	12	47	0	1	0	1	0	1	0	1	P	P
9	Surveillance technologies to detect behaviour e.g. RADAR / Glass fibre sensing devices	17	17	211	51	0.02	0.10	0.02	0.10	4	21	1	5	0	1	0	0	0	0	0	0		
10	CCTV cameras/motion detectors, linked to (train)traffic stop warnings e.g. use of CCTV technologies, but with the addition of better links to traffic control systems	11	11	143	39	0.05	0.30	0.02	0.10	7	43	1	4	0	1	0	0	0	0	0	0		
11	Information sharing at regional level e.g. Surveillance based on local intelligence from the police or health authorities	15	0	285	0	0.02	0.10			6	29	0	0	0	1	1	1	0	0	0	0	P	
12	Campaigns to raise awareness e.g. Targeted campaigns for the general public or towards vulnerable groups for suicide or trespass	22	21	357	156	0.02	0.10	0.02	0.10	7	36	3	16	1	1	1	1	1	1	1	1	R	P
13	Education in and outside schools e.g. as part of lessons in the curriculum or part of community activities	0	23	0	141			0.02	0.10	0	0	3	14	0	0	0	0	1	1	1	1	R	

ID	Types of measures	Total qualitative evaluation criteria score		Assumed number of fatalities in target group		Effect on targeted fatalities % reduction – presented as a range.				Estimated reduction in the annual number of fatalities				Categorisation criteria ("1" indicates passing of threshold value)								Classification R = recommended P = promising	
						Suicides		Trespass		Suicides		Trespass		Scores for Suicides				Scores for Trespass					
		Suicides	Trespass	Suicides	Trespass	Min	Max	Min	Max	Min	Max	Min	Max	Total qual.	Safety effect	Implement.	Survey	Total qual.	Safety effect	Implement.	Survey		Suicides
14	Mass media campaigns e.g. National campaigns, campaigns about safety	21	21	1427	391	0.00	0.05	0.01	0.05	0	71	4	20	1	1	1	0	1	1	1	0	P	P
15	Media Guidelines e.g. Media guidelines to avoid copycat effects, announcements made to passengers after an incident, removal of death memorials	22	21	714	196	0.03	0.15	0.00	0.05	21	107	0	10	1	1	1	0	1	0	1	0	P	
16	Staff Support (staff at risk of suicide) e.g. to support staff who might be at greater risk following a suicide event	22	0	10	0	0.10	0.40			1	4	0	0	1	0	1	0	0	0	0	0		
17	Additional technologies for train drivers e.g. spotlights, in-cab CCTV, additional technologies that could be available to drivers in their cab	13	14	143	39	0.01	0.10	0.01	0.05	1	14	0	2	0	1	0	0	0	0	0	0		
18	Emergency button at unstaffed stations e.g. linked to a helpline or security staff	16	14	186	68	0.00	0.02	0.00	0.02	0	4	0	1	0	0	0	0	0	0	0	0		
19	Training of staff at stations - Gatekeeper training e.g. training of frontline staff who may be able to intervene to prevent an incident	19	0	70	0	0.02	0.10			1	7	0	0	0	0	1	0	0	0	0	0		
20	Training of staff at stations - General Awareness Rising e.g. raising awareness of general risks of access to the railway, not necessarily suicide	22	22	37	0	0.01	0.05			0	2	0	0	1	0	1	0	1	0	1	0		
21	Training of drivers / instructions to drivers e.g. about responding to incidents or risky behaviours	17	17	2854	196	0.00	0.05	0.00	0.05	0	143	0	10	0	1	0	0	0	0	0	0		
22	Outreach support by trained staff on call e.g. includes signs and helplines to get support from trained staff	19	0	699	0	0.02	0.10			14	70	0	0	0	1	1	0	0	0	0	0		
23	Design of stations and other locations to influence the movements of people e.g. various physical interventions such as floor markings on areas of the platform, design of access gates, removal of places for hiding	20	20	440	146	0.00	0.05	0.00	0.15	0	22	0	22	0	1	1	0	0	1	1	0		
24	Design of stations and other locations e.g. various environmental influences such as colours, lighting, music and other devices	17	17	140	27	0.01	0.05	0.01	0.05	1	7	0	1	0	0	1	0	0	0	1	0		
25	Fences at stations e.g. Mid-platform fencing, fencing platform ends, anti-trespass grids	23	21	148	55	0.50	0.80	0.50	0.80	74	118	28	44	1	1	1	1	1	1	1	1	R	R
26	Fences outside stations e.g. Fencing at hotspots, nets at bridges	22	22	211	51	0.20	0.40	0.20	0.40	42	84	10	20	1	1	1	1	1	1	1	1	R	R

ID	Types of measures	Total qualitative evaluation criteria score		Assumed number of fatalities in target group		Effect on targeted fatalities % reduction – presented as a range.				Estimated reduction in the annual number of fatalities				Categorisation criteria ("1" indicates passing of threshold value)						Classification R = recommended P = promising			
						Suicides		Trespass		Suicides		Trespass		Scores for Suicides			Scores for Trespass						
		Suicides	Trespass	Suicides	Trespass	Min	Max	Min	Max	Min	Max	Min	Max	Total qual.	Safety effect	Implement.	Survey	Total qual.	Safety effect	Implement.	Survey	Suicides	Trespass
27	Design and landscaping of the railway environment e.g. providing alternative pathways, safe crossing areas, using natural vegetation as barriers	19	17	73	25	0.05	0.20	0.20	0.40	4	15	5	10	0	1	1	0	0	0	1	0		
28	Suicide pits at stations e.g. design of the track areas to reduce the opportunity for people to make contact with the train after jumping off platforms	10	0	74	0	0.02	0.10			1	7	0	0	0	0	0	0	0	0	0			
29	Safety and emergency information at stations e.g. Emergency information to ensure rapid intervention, information encouraging help seeking for people with suicidal intent	23	23	371	137	0.01	0.05	0.01	0.05	4	19	1	7	1	1	1	0	1	0	1	0	P	
30	Prohibitive signs	0	24	0	127			0.02	0.20	0	0	3	25	0	0	0	0	1	1	1	0		P
31	Posters and warning signs	0	23	0	196			0.02	0.10	0	0	4	20	0	0	0	1	1	1	1	1		R
32	Airbags in front of trains e.g. airbags or nets to reduce the impact of trains in the event of a collision with a person	9	9	285	78	0.05	0.25	0.05	0.25	14	71	4	20	0	1	0	0	0	1	0	0		
33	Design of trains to reduce the effects of impact e.g. removing sharp, angular protrusions that would cause greater injury	17	17	57	16	0.00	0.01	0.01	0.05	0	1	0	1	0	0	0	0	0	0	0	0		
34	Transfer of cost to family members e.g. in an effort to prevent people taking the decision to take their life or take risks on the railway as a result of costs that would be borne by others	21	0	2569	0	0.00	0.05			0	128	0	0	1	1	0	0	0	0	0	0		
35	Collaboration between organisations e.g. Clarification of responsibilities, communication strategy, consultation with psychiatric hospitals	22	22	714	196					0	0	0	0	1	0	1	1	1	0	1	0	P	
36	Risk assessment e.g. Identification of hotspots, planning for special circumstances	24	24	714	196					0	0	0	0	1	0	1	0	1	0	1	1	P	P
37	Learning from best practice e.g. Learning from international experience, previous national experience and research studies	25	25	714	196					0	0	0	0	1	0	1	0	1	0	1	0	P	P
38	Societal collaboration to prevent railway suicides e.g. National prevention strategies, such as better coordination and fast response from all emergency services in the event of an incident or threat of incident	22	20	285	78	0.05	0.30	0.02	0.10	14	86	2	8	1	1	1	0	0	0	1	0	P	

Table 2 Summary of the evaluation results

ID	Types of measures	Weights	Scores for suicides								Scores for trespassing											
			Durability of effects	Costs / benefits	Impact on railway operations	Transferability	Integration with other policy measures	Impact on people and goods	Technological issues	Environment	Acceptance	TOTAL SCORE	Durability of effects	Costs / benefits	Impact on railway operations	Transferability	Integration with other policy measures	Impact on people and goods	Technological issues	Environment	Acceptance	TOTAL SCORE
1	Alternative to railway suicide		4	4	4	0	2	2	2	2	0	20	not applicable									
2	Light to increase visibility at hotspots		4	4	4	4	1	2	2	1	1	23	2	2	4	4	1	2	2	1	1	19
3	Temporary speed reduction or traffic shut-down when a risk is detected.		4	0	0	4	0	2	2	2	0	14	4	0	0	4	0	2	2	2	0	14
4	Landscaping		4	4	4	4	1	2	2	1	1	23	4	4	4	4	1	2	2	1	1	23
5	Surveillance to deter and prevent incidents: CCTV cameras		0	4	4	2	1	2	2	2	1	18	0	2	4	2	1	2	2	2	1	16
6	Lighting devices to influence behaviour		4	4	4	4	2	2	1	1	1	23	4	2	4	4	2	2	1	1	0	20
7	Detection and surveillance systems		4	4	4	4	2	2	2	1	1	24	2	2	4	4	1	2	2	1	1	19
8	Patrols and enforcement		0	0	4	4	2	2	1	2	2	17	0	0	4	4	2	2	1	2	2	17
9	Surveillance to influence behaviour: RADAR/ Glass fibre sensing		2	2	2	4	1	2	0	2	2	17	2	2	2	4	1	2	0	2	2	17
10	Video cameras/motion detectors, mobile CCTV, linked to train stop warnings		4	2	2	0	0	1	0	2	0	11	4	2	2	0	0	1	0	2	0	11
11	Information sharing at regional level		2	2	2	2	1	1	2	2	1	15	not applicable									
12	Campaigns to raise awareness		2	4	4	2	2	2	2	2	2	22	2	4	4	2	2	2	2	2	1	21
13	Education in and outside schools		not applicable								2	4	4	4	2	1	2	2	2	23		
14	Mass media campaigns		2	4	4	2	2	2	2	2	1	21	2	4	4	2	2	2	2	2	1	21
15	Media Guidelines		2	4	4	2	2	2	2	2	2	22	2	4	4	2	2	2	2	2	1	21
16	Staff Support (staff at risk of suicide)		2	4	4	4	2	1	2	2	1	22	not applicable									
17	Additional technologies for train drivers (e.g. spotlights, in-cab CCTV)		4	0	2	4	0	0	0	2	1	13	4	0	2	4	0	1	0	2	1	14
18	Emergency button at unstaffed stations		4	2	0	2	2	1	2	2	1	16	4	0	0	2	2	1	2	2	1	14
19	Training of staff at stations - Gatekeeper training		4	2	4	2	1	1	2	2	1	19	not applicable									
20	Training of staff at stations - General Awareness Raising		4	4	4	2	2	1	2	2	1	22	4	4	4	2	2	1	2	2	1	22

ID	Types of measures	Weights	Scores for suicides								Scores for trespassing												
			Durability of effects	Costs / benefits	Impact on railway operations	Transferability	Integration with other policy measures	Impact on people and goods	Technological issues	Environment	Acceptance	TOTAL SCORE	Durability of effects	Costs / benefits	Impact on railway operations	Transferability	Integration with other policy measures	Impact on people and goods	Technological issues	Environment	Acceptance	TOTAL SCORE	
			2	2	2	2	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1
21	Training of drivers / instructions to drivers		4	2	0	4	1	0	2	2	2	17	4	2	0	4	1	0	2	2	2	17	
22	Outreach support by trained staff on call - signs and helplines		2	4	4	2	1	1	2	2	1	19	not applicable										
23	Design of stations and other locations to influence the movements of people		4	2	4	2	1	2	2	2	1	20	4	2	4	2	1	2	2	2	1	20	
24	Design of stations and other locations - colours, lighting, music, other devices		2	2	4	2	1	2	1	2	1	17	2	2	4	2	1	2	1	2	1	17	
25	Fences at stations		4	2	4	4	1	2	2	2	2	23	2	2	4	4	1	2	2	2	2	21	
26	Fences outside stations		2	4	4	4	2	2	2	1	1	22	2	4	4	4	2	2	2	1	1	22	
27	Design and landscaping of the railway environment		4	2	4	2	1	2	2	1	1	19	2	2	4	2	1	2	2	1	1	17	
28	Suicide pits at stations		2	0	2	4	0	1	0	0	1	10	not applicable										
29	Safety and emergency information at stations		2	4	4	4	2	2	2	2	1	23	2	4	4	4	2	2	2	2	1	23	
30	Prohibitive signs		not applicable								2	4	4	4	2	2	2	2	2	2	24		
31	Posters and warning signs		not applicable								2	4	4	4	2	2	2	2	1	23			
32	Airbags in front of trains		4	0	0	2	1	0	0	2	0	9	4	0	0	2	1	0	0	2	0	9	
33	Design of trains to reduce the effects of impact		4	0	2	4	2	2	0	2	1	17	4	0	2	4	2	2	0	2	1	17	
34	Transfer of cost to family members		4	2	4	4	2	1	2	2	0	21	not applicable										
35	Collaboration between organisations		2	2	4	4	2	2	2	2	2	22	2	2	4	4	2	2	2	2	2	22	
36	Risk assessment		4	4	4	2	2	2	2	2	2	24	4	4	4	2	2	2	2	2	2	24	
37	Learning from best practice		4	4	4	4	2	2	2	2	1	25	4	4	4	4	2	2	2	2	1	25	
38	Societal collaboration to prevent railway suicides		4	4	2	4	1	2	2	2	1	22	4	2	2	4	1	2	2	2	1	20	

Table 3 Scores given to different qualitative evaluation criteria.

ID	Types of measures Including examples of specific measures	Classification for prevention R=Recommended P=Promising Suicide Trespass		Commentary on the mechanism underlying the effect of the safety measure and strength of evidence in the literature ++strong, + good, - absence of evidence, plus a summary of evidence in the literature
6	Lighting devices to influence behaviour e.g. Dispelling light source, lighting linked to movement sensor	R		Environmental design to influence attractiveness of the railway for suicide or persuade people to leave a place of danger + Dispelling light sources have been evaluated in Japan. An initial study (Matsubayashi et al. 2013) reported that blue lights reduced railway suicide by 84% at station platforms, but a follow-up study by Ichikawa et al. (2014), published after the expert workshop, criticises this result and argues that the effect is severely overestimated.
7	Detection and surveillance systems e.g. Intelligent CCTV combined with sound warnings	R		Surveillance for early warning or persuade people to leave a place of danger + DaSilva et al. (2006) have shown the effectiveness of intelligent CCTV combined with sound warnings on a railway bridge in the USA, where the trespass rate dropped by 60% from the first to the second year and by 17% (compared to the first one) in the third year. Too et al. (2015) found increased numbers of video surveillance systems at railway stations was associated with a modest reduction in railway suicide risk.
12	Campaigns to raise awareness e.g. Targeted campaigns towards vulnerable groups	R	P	Education / campaigns to influence attractiveness of the railway for suicide - Mentioned in the following literature, but not studied in any depth - (Bureau of Transport and Regional Economics 2002; CARE 2006; DaSilva and Carroll 2011; Horton 2009; Lobb et al. 2001; Lobb et al. 2003; Mishara 2007; Mohanty et al. 2007; Pelletier 1997; RSSB 2002; RSSB 2003; RSSB 2012).
13	Education in and outside schools		R	Education / campaigns to influence attractiveness of the railway for trespass + Education at schools dedicated to risk and safety helped reduce trespass behaviour when combined with communication and enforcement (Lobb et al. 2003) or fencing and signage (Lobb et al. 2001).
25	Fences at stations e.g. Mid-platform fencing, fencing platform ends, anti-trespass grids	R	R	Physical measures to influence access to the tracks ++ Strong evidence from multiple studies in various countries, with access restriction through different types of fencing and barriers (e.g. sliding doors at platforms, nets at bridges, or fencing at stations and open line hotspots). Cox et al. (2013) reported strong evidence of the effect of reducing means of access to suicide, without substitution effects. Pirkis et al. (2015) reported how restricting access to means of suicide was associated with a reduction in risk of suicide. Physical barriers found to reduce fatalities at suicide hotspots by 59% (Law et al. 2009; Law and Yip 2011), 76% (Ueda et al. 2015 for half-height platform screen doors) and 100% (Beautrais at al. 2009 – nets at bridges) and reduce trespassing behaviour between 23% (Lobb et al. 2001) and 95% (Silla and Luoma 2011) at trespass priority locations. Positive effects of fencing are also reported by Reisch and Michel (2005), Hepp et al. (2012), and Pirkis et al. (2015) against suicide by jumping.
26	Fences outside stations e.g. Fencing at hotspots, nets at bridges	R	R	
31	Posters and warning signs		R	Education / warnings to influence attractiveness of the railway for suicide or persuade people to leave a place of danger + Lobb et al. (2001) evaluated the effect of warning signs and posters in combination with fencing and education and found that it significantly decreased trespass at a railway station in New Zealand.

ID	Types of measures Including examples of specific measures	Classification for prevention R=Recommended P=Promising Suicide Trespass		Commentary on the mechanism underlying the effect of the safety measure and strength of evidence in the literature ++strong, + good, - absence of evidence, plus a summary of evidence in the literature
2	Light to increase visibility at hotspots e.g. Lighting at identified hotspots	P		Environmental design to influence attractiveness of the railway for suicide, enable early warning or persuade people to leave a place of danger - Mentioned in the following literature, but not studied in any depth - (Erazo et al. 2005; Offler et al. 2009; Savage 2007; Mishara 2007; Thompson et al. 2012; van Houwelingen 2011)
4	Landscaping e.g. Removal of vegetation to increase visibility	P		Environmental design to influence attractiveness of the railway for suicide and enable early warning - Mentioned in the following literature, but not studied in any depth - (Andriessen and Krysiniska 2011; Debbaut et al. 2013; Horton 2009).
8	Patrols and enforcement e.g. Security patrols, security patrols able to fine	P	P	Surveillance to influence the attractiveness of the railway for suicide and to enable early warning + Security patrols against suicide are supported by Niederkrotenthaler et al. (2012) who have shown that the presence of a surveillance unit at stations is associated with a decrease of suicidal behaviours. The study by Lobb et al. (2003) also indicates that combining punishment with intermittent reinforcement of desired behaviour (i.e. rewards) significantly reduced trespass behaviour in male pupils, thus supporting recommendations for security patrols who are able to fine.
11	Information sharing at regional level e.g. Surveillance based on local intelligence	P		Surveillance to enable early warning - No references in the literature.
14	Mass media campaigns e.g. National campaigns, campaigns about safety	P	P	Education / warnings to influence attractiveness of the railway for suicide + Mentioned in the following literature, but not studied in any depth - (Bureau of Transport and Regional Economics 2002; CARE 2006; DaSilva and Carroll 2011; Horton 2009; Lobb et al. 2001; Lobb et al. 2003; Mishara 2007; Mohanty et al. 2007; Pelletier 1997; RSSB 2002; RSSB 2003; RSSB 2012).
15	Media Guidelines e.g. Media guidelines to avoid copy cat effects, announcements made to passengers after an incident, removal of death memorials	P		Education / warnings to influence attractiveness of the railway for suicide ++ Evaluation studies in different countries have reported significant increase in railway suicide following media reports of suicide incidents (Kunrath et al. 2011), moderately strong impact of media reporting (Too et al. 2014); strong copy cat effect following celebrity suicide (Hegerl et al. 2013; Koburger et al. 2015; Ladwig et al. 2012), imitation of suicide means if reported in the media (Yang et al. 2013), and contagion, especially in the groups whose age and sex were closest to those within the media report (Schmidtke and Häfner 1988). In addition, implementation of media guidelines in Vienna underground resulted in a significant decrease of suicide cases (Etzersdorfer and Sonneck 1998) and suicidal behaviours (Niederkrotenthaler and Sonneck 2007) providing strong support for effectiveness.

ID	Types of measures Including examples of specific measures	Classification for prevention R=Recommended P=Promising Suicide Trespass		Commentary on the mechanism underlying the effect of the safety measure and strength of evidence in the literature ++strong, + good, - absence of evidence, plus a summary of evidence in the literature
29	Safety and emergency information at stations e.g. Emergency information to ensure rapid intervention, information encouraging help seeking for people with suicidal intent	P		Education / warnings to influence attractiveness of the railway for suicide, to enable early warning or persuade people to leave a place of danger - Mentioned in the following literature, but not studied in any depth - (Andriessen and Kryszynska 2011; du Roscoät and Beck 2013; Holdaway et al. 2012; Kerkhof 2003; Ladwig et al. 2009; Mishara 2007; Routley et al. 2004). Recently, Pirkis et al. (2015) reported how encouraging help-seeking was associated with a reduction in risk of suicide.
30	Prohibitive signs		P	Information to influence access to the tracks and persuade people to leave a place of danger + Silla and Luoma (2011) evaluated the effectiveness of prohibitive signs at a trespass hotspot in Finland and found that trespass behaviour dropped by 30.7%.
35	Collaboration between organisations e.g. Clarification of responsibilities, communication strategy, consultation with psychiatric hospitals	P		Organisational / inter-organisational approaches - Mentioned in the following literature, but not studied in any depth - (Baumert et al 2011; Bureau of Transport and Regional Economics 2002; CARE 2006; DaSilva et al. 2006; George 2007; Lobb et al. 2001; Patterson 2004; RSSB 2005; RSSB 2011; Thompson et al. 2012).
36	Risk assessment e.g. Identification of hotspots, planning for special circumstances	P	P	Organisational / inter-organisational approaches - Mentioned in the following literature, but not studied in any depth – for risk assessemnt (Bhui et al. 2013; Debbaut et al. 2013; Erazo et al. 2004; Lukaschek et al. 2014; Niederkrotenthaler et al. 2012; Routley et al. 2004; van Houwelingen and Kerkhof 2008), station audits (RSSB 2013), and follow-up processes (RSSB 2012).
37	Learning from best practice e.g. Learning from international experience, previous national experience and research studies	P	P	Organisational / inter-organisational approaches - No references in the literature.
38	Societal collaboration to prevent railway suicides e.g. National prevention strategies	P		Organisational / inter-organisational approaches + Baumert et al. (2011) have shown that the German national railway suicide prevention strategy had positive results, reducing the number of suicides by almost 14%

Table 4 Recommended and promising measures for the prevention of railway suicides and trespassing, including comparison evidence from the literature.

Type of comment	Examples
Practicalities or limitations of measures	<p>It was explained how some measures might work in practice e.g. outreach workers at a station.</p> <p>The durability or longevity of measures was mentioned e.g. the need for repeated application of some measures, such as education in schools as children grow up and new cohorts come along.</p>
Potential negative impacts of measures	<p>There may be some unexpected effects in some geographical locations e.g. removal of vegetation could impact on soil erosion in countries such as Turkey, or impacts on delay costs of stopping trains after receiving warnings of trespass.</p> <p>There is the potential for distraction if drivers need to monitor CCTV displays in the cab e.g. on the line ahead.</p>
Identification of new measures	<p>Examples included glass fibre sensor cables to detect trespass along the length of the railway line, including how people would need to react to the triggering of the sensor and impacts on delay costs if trains were required to slow down.</p> <p>There can also be difficulties in applying media guidelines as new media emerge.</p>
Problems applying the methodology	<p>There can be difficulties providing ratings for some measures, such as where their definition is quite wide ranging (e.g. the design of stations and other locations).</p>

Table 5 Examples of commentary on the implementation and likely success of different measures

Groupings of different types of preventative measures	Recommended or promising measures for prevention Count of categories of types of measures <i>[ID numbers – see table 2 for details]</i>	Questionable measures in terms of prevention Count of categories of types of measures <i>[ID numbers – see table 2 for details]</i>	Comparison with findings from Havârneanu et al, 2015 – showing the order based on citation statistics and the description of the measure used in the paper
Awareness / education (including various types of campaigns, education in schools, media guidelines, signs and information at stations)	6 <i>[12, 13, 14, 15, 29, 31]</i>		5. Education and enforcement at individual level 7. Public safety communication 8. Signage 17. Appropriate reporting or broadcast of critical incidents
Organisational initiatives (including collaboration between organisations, risk assessment and learning from best practice)	4 <i>[35, 36, 37, 38]</i>	1 <i>[16]</i>	2. Collaboration between institutions 11. Risk assessment 12. Learning from previous research and best practice
Physical and other measures to restrict access (including fences and prohibition signs)	3 <i>[25, 26, 30]</i>		1. Fencing and other physical barriers
Environmental design (including layouts or stations, aesthetics, landscaping to reduce access, pits beneath tracks)	3 <i>[2, 4, 6]</i>	4 <i>[23, 24, 27, 28]</i>	3. Environmental design 13. Lighting systems to influence behaviour 15. Design aesthetics to influence behaviour
Surveillance (including sensors, CCTV, training of staff / outreach workers, public operated emergency buttons)	3 <i>[7, 8, 11]</i>	7 <i>[5, 9, 10, 18, 19, 20, 22]</i>	4. Monitoring and detection systems 6. Enforcement, punishment and controls 10. Staff training 18. Emergency information and outreach support at hotspots
Dissuading use of the railway for suicide (including charging family costs and promoting other alternatives for suicide)		2 <i>[1, 34]</i>	19. Decrease attractiveness of the railways as a lethal method
Train driver support (including technological and training solutions)		2 <i>[17, 21]</i>	14. Additional technologies for train drivers
Train design (including airbags and redesign of the fronts of trains)		2 <i>[32, 33]</i>	9. Technical design to reduce the effects of impact
Operational traffic management (e.g. stopping trains when a risk is identified)		1 <i>[3]</i>	16. Operational train management

Table 6 Selection of different types of preventative measures for suicide and trespass from applying the evaluation methodology

Mechanisms of effect of the preventative measures	Recommended or promising measures for prevention Count <i>[ID numbers – see table 2 for details]</i>	Questionable measures in terms of prevention Count <i>[ID numbers – see table 2 for details]</i>
Influencing the attractiveness or availability of the railway for suicide	10 [2, 4, 6, 8, 12, 13, 14, 15, 21, 31]	6 [1, 3, 5, 23, 24, 34]
Influencing access to the railway	3 [26, 27, 30]	2 [23, 27]
Early warning of risk of incident	6 [2, 4, 7, 8, 11, 29]	6 [5, 9, 10, 19, 20, 22]
Persuading people to leave a place of risk	6 [2, 6, 7, 29, 30, 31]	3 [17, 18, 19]
Mitigation of consequences of collision	0	5 [17, 21, 28, 32, 33]
Organisational / inter-organisational	4 [35, 36, 37, 38]	1 [16]

Table 7 Classification of selected and non-selected preventative measures by different mechanisms of effect (Extended from Rådbo et al, 2008)

