Railway Suicides in the UK:
risk factors and prevention strategies

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Foreward

Suicide is a tragic event with far reaching impact on the lives of those touched by it. Initiatives that seek to better understand the causes and opportunities for suicide prevention are ever more important as public health experts report increasing rates of mental ill health in the current economic climate. This report is the work of an impressive collaboration between the transport agencies, the health service, leading academics and local communities in London. The report is a helpful analysis of the international learning in suicide prevention related to transport hubs, and makes useful recommendations about the physical and support improvements that can be made in these environments. It makes a helpful distinction between methods that can be put in place to prevent suicide for those already known to mental health services, and the need to further understand, and address the societal factors that lead vulnerable individuals to end their lives, without first appearing to seek help. Importantly, its recommendations point to the need for new local community leadership collaborations, between health and well being boards, public health, local government, and commissioners of primary care and specialist mental health services. It urges these community partnerships to commission more research to understand and address the social and cultural determinants of mental ill health; to explore how to commission appropriate capacity and capability in local social care and wider local government services, and in primary care and specialist mental health services; it urges a review of how to put in place whole system local governance and safeguarding systems that enable local networks to develop sustainable improvements in the care and support of vulnerable people.

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Executive Summary

Falling rates of rail suicide (in excess of background population rates) for some European nations have shown the effectiveness of preventative measures. Physical barriers have been shown to be particularly effective.

To date, research into the seasonality, day of the week and time of rail suicides has yielded little data that can be translated into practical measures.

No research has been conducted into the socio-economic status and ethnicity of those who commit suicide on the UK railway system. It appears that the proportion of females who commit rail suicide is rising. This data is potentially of value in designing psychological interventions.

An association has been widely reported between mental illness and railway suicide. It is thought to be a function of proximity to in-patient psychiatric units and severe forms of mental illness, such as schizophrenia. Some of these findings are disputed and more needs to be discovered about this association.

Rail suicide is considered to be an impulsive act rather than a carefully considered strategy. Evidence from Japan suggests that the installation of calming blue lights at hotspots significantly reduces rail suicides. There may be other interventions that delay or calm decision making.

An association exists between passenger numbers and rates of suicide. Some London hotspot stations are the busiest on the system. There may be an effect from crowding itself and that a high-density population in a confined platform encourages impulsive behaviour. This hypothesis requires further research.

Preventative measures do not result in the substitution of another method. Studies have found that slightly increased rates at neighbouring sites do not cancel out overall reductions in rail suicides.

ABBREVIATIONS USED IN THE TEXT

BTP	British Transport Police
CI	Confidence interval
ERA	European Railway Agency
LUL	London Underground Limited
OR	Odds ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RSSB	Rail Safety and Standards Board
SPSI	Social problem solving ability
TfL	Transport for London

Introduction

In 1897, Émil Durkheim argued that 'the more the land is covered in railroads, the more general becomes the habit of seeking death by throwing one's self under a train' (Durkheim, 1897, 292). According to the official statistics of the Registrar General, the first railway suicide was reported in 1852 and 10,042 rail suicides (2.9%) were recorded in England and Wales during the period 1852-1949 (Clarke, 1994). Throughout this period the number of male cases always exceeded the number of female cases and by the early decades of the twentieth century, railways accounted for 5% to 6% of male suicides and 3% to 4% of female suicides. The rising incidence of railway suicide in England and Wales correlated with the growth of the railway system and number of passengers; the rate rose in direct association with the availability of the means. This historical evidence suggests that as the Underground expands in extent and the frequency of services increases, then the number of suicides will rise.

Between 1960 and 1990 the annual number of railway suicides in England and Wales increased by 40% (O'Donnell, Farmer and Tranah, 1994). By 1990 London had one of the highest rates of railway suicide (1.2 per 10 million passengers), which compared poorly with Singapore (0.0) and Tokyo (0.2); only Rio de Janeiro (1.7) and Paris (1.8) had higher rates. These national variations suggested that suicidal behaviour on the railways could be effectively addressed by preventative measures. An international conference was held in April 1991 to gather epidemiological evidence and to suggest practical ways of reducing the number of deaths. The results, published in a special edition of Social Science and Medicine, prompted London Underground to introduce a range of preventative measures such as gates to tunnel entrances, platform-edge marking, CCTV to monitor levels of crowding at stations, platform-edge doors and restrictions on public reporting of railway suicides.

Research conducted by Charing Cross and Westminster Medical School and funded by London Underground revealed a statistically significant increase in the mean annual number of railway suicides on the Underground, rising from 36.1 deaths between 1940 and 1949 to 94.1 between 1980 and 1989 (O'Donnell and Farmer, 1994). The majority of incidents (almost 90%) took place on platforms and of these 40% occurred within one carriage length from the point at which the train entered the station and was travelling at its highest speed. Fourteen hotspot stations were identified that accounted for 24% of all deaths. For two stations with the highest numbers of deaths, specifically King's Cross with 34 deaths and Victoria with 22 deaths between 1981 and 1990, the higher risk was explained by the high volume of passengers that pass through these stations. Mortality statistics were related to passenger numbers to identify stations with greater than predicted deaths to analyse their characteristics. Mile End station, for example, recorded 22 deaths, significantly more than the four predicted on the basis of its passenger numbers. Tooting Bec station recorded 16 deaths but had a predicted total of only three. It was argued that many high-risk stations were close to psychiatric hospitals and that the incidents involved patients receiving treatment. It was also concluded that suicide was often an impulsive action, and that the introduction of preventative measures would not necessarily lead to the substitution of alternative methods.

The Rail Safety and Standards Board (RSSB) reported a progressive rise in suicides and suspected suicides from 192 in 2001-02 to a peak 233 in 2009-10, the total falling to 208 in 2010-11. Most occurred on the running line outside of stations, though the proportion of all rail suicides occurring at stations had slowly risen, from 33% in 2001-02 to 40% by 2009-10. Equally, the percentage at railway crossings was also rising from 7% in 2001-02 to 15% by 2009-10 (RSSB, 2009-10, p. 128; RSSB, 2010-11, p. 134). The fall in suicides recorded in 2010-11 (down to 208 from 233 in 2009-10) may be as a result of a public campaign, 'Men on the Ropes'. As part of a five-year partnership between Network Rail and the Samaritans, launched in January 2010, 'Men on the Ropes' was designed to reduce rail suicides by 20% over a five-year period, largely by training key railway staff in how to manage trespassers and those at risk of suicide. As a proportion of all suicides in the UK, railway suicides rose from 3.2% to 3.4% between 2001/02 to 2004/05, 4.4% in 2006-07, and 4.2% in 2008-09 (RSSB 2010-11, 135).

A study of German railway suicides covering the period 2002 to 2006, found that jumping (32.2%), lying on tracks (32.6%) and walking along lines (34.2%) occurred in almost equal frequencies (Dinkel et al., 2011). However, jumping occurred between 9 am and 6 pm but was most common around midday and most often in station areas. Age and gender could not be used to explain different methods of suicide.

A general feature discovered by Thomas et al. (2013) is that the proportion of females committing suicide in the UK by jumping in front of a train has increased. Figures obtained from the Office of National Statistics for the period 1901-1907 showed that the overall percentage using this method was 4.2% compared with 4.6% between 2001 and 2007. However, female suicides from jumping rose from 2.2% to 4.4%, whilst male deaths were 4.9% and 4.7%, respectively.

Official figures reported by the British Transport Police for the years 2007, 2009 and 2011 suggest there 22, 25 and 17 suicides, respectively for each calendar year; and 17 , 18 and 27 injurious attempts (personal communication, 7th October, 2013). However, there are widely different figures reported in the press. One press report, ostensibly sourced from Transport for London, suggests deaths from suicide on London Underground have risen from 46 in 2000 to to 61 in 2007, 82 in 2009 and 80 in 2011 despite a range of precautionary measures introduced in the previous decade (Harper, 2011). Clearly a consistent reporting framework is required. In view of continuing concerns about prevention, three reviews were conducted over this period, two by external consultants (Zeal Solutions, 2007; Holdaway et al, 2010) and one by British Transport Police (Kisby, 2008).

1. BACKGROUND

1.1   Explanatory models of suicide

A number of psychological processes have been proposed to explain such a dramatic and serious event as suicide. They include loss of control (Pavulans et al., 2012) and hope (Wong et al., 2011) through defeat, (Taylor et al., 2011) entrapment, (Taylor et al., 2011) and guilt (Ventrice et al., 2010), together with a failure to meet expected norms or standards (Chatard and Selimbegović, 2011). Population studies show that individuals who repeatedly attempt suicide predominantly suffer from affective or anxiety disorders, are middle aged, and are at increased likelihood for alcohol and substance abuse; they have also experienced more intensive psychological treatment than those who make one or few attempts (Lopez-Castroman et al., 2011).

Koeda et al. (2012) sought to compare suicide of patients with schizophrenia with suicides among patients with depressive disorders, Koeda et al. (2012) found that the group with a diagnosis of schizophrenia used more serious methods, such as jumping from high places and throwing oneself in front of an oncoming train; hallucinations and delusions accounted for an overwhelmingly large percentage of motives and causes. The groups were age-matched. They found that the ratio of 'no-housemate' patients was high among the elderly and that joblessness was common in all age groups. Among those with a diagnosis of schizophrenia, the severity of the method of attempted suicide was positively correlated with a history of attempted suicide in the preceding year.

The interpersonal theory of suicide proposes that the 'most dangerous form of suicidal desire is caused by the simultaneous presence of two interpersonal constructs – thwarted belongingness and perceived burdensomeness, and hopelessness about these states' (Van Orden et al., 2010, 575). It argues for an important distinction between the capability and the desire to engage in suicidal behaviour. Earlier versions of the theory (such as Joiner, 2005) have been refined and the theory currently gives strong support for suicidal ideas arising from habituation (Van Orden et al., 2010). Thus, through repeated practice and exposure, an individual can habituate to the painful and fearful aspects of self-harm, making it possible for him or her to engage in escalating levels of physically damaging and lethal forms of self-harm. Further, increased likelihood of committing suicide is presumed to be associated with a lowered fear of death and increased tolerance of physical pain. Other studies conducted with those who had survived suicide attempts explored thoughts about the crises they have experienced (Vatne and Nåden, 2012). The authors identified five key themes in the narratives of survivors: losing touch with the world, a relationship between the act of suicide and life history (events and conditions in earlier stages of life that have contributed to the decision), struggling for death and life (suicide as an expression of a struggle between seeking a relief from suffering and a longing for life), an open door as consolation (suicide as an option to put an end to suffering), and feeling shame and guilt.

The above is a psychological interpretation of suicide but sociological factors should also be considered particularly in relation to death from jumping in front of a train. Durkheim's classic study argues that rates of suicide are determined in general by socio-cultural factors:

> 'There is, in short, in a cohesive and animated society a constant inter-change of ideas and feelings from all to each and each to all, something like a mutual moral support, which instead of throwing the individual on his own resources, leads him to share in the collective energy and support his own when exhausted (Durkheim, 1952, 210).'

Durkheim had argued that rates of suicide among French Roman Catholics were lower than recorded for Protestants because of greater social integration and control. Although the reliability of his data has been questioned, many have accepted the underlying argument. It was argued, for example, that suicide rates in the UK fell during the Second World War (from 12.9 per hundred thousand to 8.9 in 1944) because of a collective sense of purpose and improved networks of mutual support (Calder, 1969, 357).

However, a recent study has shown that this interpretation did not apply to all groups and sub-populations showed rising rates. Henderson et al. (2006) found that the male suicide rate in Scotland rose between 1940 and 1943, especially in the under-45 age group. This was against the long-term trend and the means of suicide proved to be critical. Suicide using firearms and explosives was the only method that increased significantly during the war, leading the authors to conclude:

> 'Younger men are the groups most likely to be called to arms, and to have access to guns. It seems likely, therefore, that the stresses of being a potential combatant, and access to lethal methods of self-harm, were important contributors. This is supported by the minimal impact the war had on female suicide trends (Henderson et al., 2006, 173).'

Hence, it may be the case that those who jump in front of trains can be categorised as belonging to one or more sub-groups – disaffected individuals with problems at work or with limited social networks. Alternatively, they may be individuals particularly prone to impulsive behaviour. Jumping under a train is an angry way of committing suicide (compared with taking an overdose) as it causes distress to the driver and often disrupts the travel of hundreds of commuters.

Data from the military may provide some context: a series of high-profile suicides of young soldiers in the British Army led to accusations of bullying and studies to identify whether rates were significantly higher than in age-matched background population. Fear et al. (2009) found that between 1984 and 2007, 694 male members of UK armed forces committed

suicide. For each age group, the number was lower than the expected number based on general population rates in the UK, apart from Army males under the age of 20, who were 1.5 times more likely to commit suicide than expected. Pinder et al. (2011) found a lifetime prevalence of 5.6% for intentional self-harm (self-harm or attempted suicide) from self-report data. Intentional self-harm was associated with psychological morbidity (in particular, post-traumatic stress disorder) and adverse experiences in childhood. Ex-service personnel reported lifetime prevalence more than double that of serving personnel (10.5% versus 4.2%, respectively). Participants reporting intentional self-harm were younger (34.4 years versus 39.8 years). Those who left the armed forces early, those who experienced childhood adversity, those with other psychological morbidity, and ex-service personnel are more likely to report self-harm behaviour. This data suggests that suicide is a form of behaviour that is shaped by culture and context.

The ideas and beliefs that motivate a person to attempt suicide cannot accurately be determined without access to information that is often difficult for suicidal people to verbalise (Biddle et al., 2012). Semi-structured interviews of psychiatric in-patients, who were assessed as being at risk of suicide, found that the most frequent sources of information about suicide were television, newspaper reports, the internet, and previous episodes of self-harm, as well as, to a lesser extent, professional resources, personal knowledge of others' attempts and information gleaned from healthcare professionals (Biddle et al., 2012). Indeed, several of the respondents reported that they were directly imitating suicides that they had encountered in the media.

1.2 Psychiatric Patients and Suicide

A number of studies have explored suicide by patients receiving psychiatric treatment at the time of the attempt (see National Confidential Inquiry into Suicide, 2013; Steeg et al, 2012; Cheng, Fu Chang and Tseng, 2009; Tishler and Reiss, 2009). Violent and unusual methods predominate among psychiatric in-patients, indicating an association between long-term treatment and suicidal tendency (Pavulans et al., 2012). In addition, suicide attempts during education before a formal psychiatric illness has emerged and during a first admission are indicators of poor long-term prognosis (Levine, Bakst and Rabinowitz, 2010). There is also evidence to suggest that psychiatric patients are vulnerable to suicide at the time of discharge or shortly afterwards (National Confidential Inquiry into Suicide, 2013; Steeg et al, 2012; Bergen et al., 2012). Reductions in the level of treatment input provided by care organisations are strongly associated with suicide by people with mental illness, and this loss of support may be contributory (Appleby et al., 1999). Although the rate of suicide for psychiatric in-patients has fallen in England, Kapur et al. (2013) found that the rate of post-discharge suicide has risen. They speculated that this might be a consequence of fewer in-patient beds, which means that community services are now managing a higher-risk group of patients. These increased risks may be less controllable in the post-discharge setting than in the in-patient setting, and may contribute to the rise in rail suicides.

Evidence about the role of intent and planning in a final suicide is inconclusive. Some data suggests that advanced planning (O'Donnell et al., 1994) is an important indicator of suicide, whilst other evidence suggests impulsivity is a key predictor (O'Donnell et al., 1996). Studies of survivors of suicide attempts have identified different pathways and precipitating events. For Latin American attempters in New York City, the path to suicide consisted of 'patterns of continuous, escalating stress (primarily at home) that created the emotionally combustible conditions for the attempt' (Zayas et al., 2010, 1773). The study highlighted loneliness and alienation as significant factors in adolescent girls who had attempted suicide as they struggled to reconcile traditional Hispanic gender norms with modern Western culture (Zayas et al., 2010, 1778). Hunt et al., (2003) found that ethnic minorities in England comprised 6% (about 70 deaths per annum) of all suicides. The study showed that culture had an influence on the method as these groups were more likely to kill themselves by jumping and less likely to self poison than the White population. The most common psychiatric diagnosis among the ethnic minorities studied was schizophrenia, and ethnic minorities, when compared with white patients, were more likely to have a history of violence and non-compliance. However, the suicide attempt was commonly consequence of the first episode of self-harm. This suggests that a history of self-harm is not always a reliable indicator of suicide risk and should not be considered the only indicator of risk. Studies in the UK examining ethnicity and suicide have shown an elevated risk in young black men compared to white men, although the risk in men is increasing in general (Bhui et al, 2008). Higher rates of suicide were reported in South Asian women (McKenzie, 2008). This is perhaps due to culturally sanctioned practices. Burning, for example, is more common in women from South Asia, although these practices are challenged by acculturation and health education (Tuck et al., 2010).

1.3 Railways and transport related suicides

The prevention of suicide is important because it causes distress to witnesses (Mehnert et al., 2012), families of those who die in this manner, as well as health care staff (Tzeng et al., 2010; Dyregrov, 2011; Davidsen, 2011; Veilleux, 2011). However, witnessing a suicide does not necessarily lead to a significant or lasting psychological disorder as some individuals are more vulnerable than others (Berman, 2011). Furthermore, Berman (2011) argues that the number of 'survivors' who suffer emotionally as a result of a suicide can vary greatly depending on the social networks of the person who has taken their life.

Acts of suicide have been shown to serve as a trigger for others to act in that way also, but amongst those with vulnerabilities (Hawton & Heeringen, 2009). Controls over the reporting of suicide by the media have shown promising preliminary findings (Hegerl et al., 2013). Railway suicides have greater capacity to cause harm than many other forms because of the significant number of potential witnesses to an event in a public and highly populated environment (Mehnert et al., 2012). Not only do many thousands pass through transport hubs on a daily basis, announcements across networks often inform passengers that disruption to services is 'because of a person under a train'.

Overall rates of suicide in the UK have been gradually falling. This is largely attributed to interventions among high-risk groups, such as patients with mental illness. However, the RSSB review also showed the numbers of suicides linked to transport hubs is increasing, in contrast to the national trend (Holdaway et al., 2010).

1.4 Causal Hypotheses

The literature has suggested a number of causal hypotheses for the continuing rise of suicides on London Underground. Although a number of studies have suggested that patients with a psychiatric diagnosis are over-represented among rail suicides, there is conflicting evidence about the association between psychiatric units and station hotspots. Farmer et al. (1991) argued that disproportionate levels of suicide in relation to passenger numbers at certain stations, such as Mile End and Tooting Bec, could be explained by their proximity to hospitals treating psychological disorders. They found that in-patients accounted for 55% of rail deaths at Tooting Bec and 22% at Mile End stations (see also O'Donnell and Farmer, 1994). In addition the SOVRN study (Abbott et al., 2003) discovered an association between in-patients who had left psychiatric units without permission or formal discharge and the location of their suicide on the railway. A systematic literature review by Krysinska and De Leo (2008) found that between 38% and 83% of rail suicides had a documented history of psychiatric illness. Data collected in the Netherlands was combined with four published studies of train suicides (one Danish, two UK and one Australian) to discover what proportion of those taking their lives were being treated for a psychological disorder (van Houwelingen and Kerkhof, 2008). They found that 53% of railway suicides were receiving psychiatric care, 49% being in-patients. Affective disorders accounted for 39% of the subjects.

A study of railway suicides in Belgium concluded that hotspots had the following characteristics: easy access to the railway due to a lack of proper fencing, proximity of level crossings, and vicinity of a medical institution (13 of 34 hotspots were close to a mental health unit) (Andriessen and Krysinska, 2011). The evidence, however, is not uniform as Symonds (1994), using a survey of rail fatalities in southern England, showed that psychiatric in-patients had not selected the station or railway line closest to their unit. Thus, the picture is unclear and suggests an opportunity for a research project to explore the relationship between psychiatric patients and rail suicide.

More recently it has been suggested that the pressures of modern life, in particular the downturn in the British economy from 2007, are the primary cause for the increase in suicide on the London Underground (Harper, 2011). There is also debate about the nature of rail suicide: whether most cases are an impulsive act rather than the outcome of a carefully considered strategy (Krysinska and De Leo, 2008). O'Donnell et al. (1996) interviewed 20 individuals who had survived a serious suicide attempt by jumping in front of a railway train. In most cases the act had been impulsive and characterised by a high level of suicidal intent (90% were certain that they would die). The majority (72%) were in treatment for a psychiatric disorder at the time of the event. This is a small sample and may be biased by the fact that

a significant number were suffering from severe psychiatric illness. The balance of views appears to favour train suicide as a function of impulsivity (which may in itself be short-lived related to immediate problems). However, none of these hypotheses have been tested against population data.

This systematic review draws on previous findings, updates them. Thus the review has surveyed the literature of railway suicide in general, but has focused in particular on papers in peer-reviewed journals published between 2010 and 2013.

Aim & Objectives

1) To increase knowledge about prevention of suicide on British Rail and Underground systems.

2) To identify risk characteristics in both individuals and environments associated with suicide attempts on the railway system.

3) To identify evidence-based suicide prevention strategies from around the world.

2. METHODS

A literature search was conducted using the search terms 'train', 'rail' 'railway', 'subway', 'metro', 'underground', matched in pairs with the terms 'suicide' and 'accident' to identify relevant papers in peer-reviewed journals. The databases used in the search are listed below in Figure 1.

Figure 1: *Databases searched for the review*

American Psychological Association (APA)
American Medical Association (CrossRef)
BioMed Central
BMJ Journals
Cambridge Journals (Cambridge University Press)
Directory of Open Access Journals (DOAJ)
HKIR - selected records
Life Sciences (JSTOR)
MEDLINE (NLM)
Nature Publishing Group (CrossRef)
Oxford Journals (Oxford University Press)
PMC (PubMed Central)
SAGE Journals
Science Citation Index Expanded (Web of Science)
SpringerLink
SciVerse ScienceDirect (Elsevier)
Social Sciences Citation Index (Web of Science)
Wiley Online Library

At the outset inclusion and exclusion criteria were defined. Peer-reviewed journal studies that were not included in or followed publication of the RSSB Review (Holdaway et al, 2010) were identified. Papers that addressed suicide and suicide attempts on railway/metro/underground/ subway/train networks were included. In addition, papers that analysed the prevalence and contributory factors of attempted/completed suicide in a Western culture were included together with papers that analysed interventions and preventative strategies. Exclusion criteria included foreign language publications and papers that addressed training and education to deal with suicide.

We searched the databases for articles (n=7,574). After removing duplicates and studies included in the RSSB Review (n=6,791), the search revealed 783 potentially relevant and new articles. By inspecting titles and abstracts, there were 390 relevant studies. For the purpose of review, epidemiological studies (the 'cause' group, n=301) were separated from prevention studies (the 'intervention' group, n=89). A total of 20 studies were included in the final selection and from these key characteristics and findings were presented in tabular form (Table 1). In this report we focus on those findings that can be analysed at a policy level for practice intervention. The majority of studies that addressed causality were excluded because prevalence or demographic information by rail suicides had not been quantified in the study. Some intervention studies were excluded because the preventative measures proposed were not under evaluated but were inferred from epidemiological information.

Table 1: Study characteristics and results

Authors and date	Study no.	General approach	Specific intervention	Study design	Findings
Ajdacic-Gross et al. (2012)	1	Qualitative review	Seasonality of suicide attempts in Western nations	Literature review from 1990s	No evidence of a seasonal effect for violent means such as railway suicide
Andriessen and Krysinka (2011)	2	Population study of incidence in Belgium 1998-2009	Prevention programme	Monthly fluctuations, geographical distribution, identification of hotspots	National differences in rates, need for effective measures
Baumert et al. (2011)	3	Population study German rail suicides 1998 to 2006	Evaluation of prevention programme	Central registry of suicides on German railway system	A significant fall in rail suicides compared with the general reduction in Germany
Biddle et al. (2012)	4	Analysis of 22 near-fatal suicide attempts	Impact of media and other information on planning and execution of suicide attempt	Semi-structured interviews of survivors	Use of media and internet to plan suicide; could be used to create a negative picture for prevention
Cox et al. (2013)	5	Systematic review and meta-analysis	Interventions for suicide hotspots including railways	Quantitative synthesis of 14 papers	Restriction of means, encourage help-seeking, third-party intervention and media restrictions
Dinkel et al. (2011)	6	Analysis of 1,004 cases of rail suicide from German National Central Registry	Analyse by type in particular jumping in front of trains	Explore relationship to gender, season, day of week and time	Jumping (32%) common between 9 am and 6 pm, most often in the middle of the day and in stations
Florentine and Crane (2010)	7	Qualitative review	Assessment of limitation to access to suicide methods	Review of physical limitations and control of information sources	Problems of conducting studies of preventative measures explored

Hegerl et al. (2013)	8	Population study of German rail suicides after the death of Enke	Assess the impact of media reporting and copycat behaviour	Comparison of rates two-years before and two-years after Enke's suicide	Significant increase in rail suicide and higher than the general increase in German suicide
Huisman et al. (2010)	9	National sample of suicides by those in psychiatric care	Assess means of suicide and association with diagnosis	Sample of 505 Dutch psychiatric patients	Violent methods associated with psychosis, no pattern to depressed patients, in-patients and bi-polar patients correlated with rail suicide
Koeda et al. (2012)	10	Comparison of Japanese schizophrenic and depressed patients who had attempted suicide	Assess the characteristics of the means of suicide	Samples from emergency hospitals and post-event interviews	Railway suicide and other serious methods correlated with severe symptomatology and schizophrenia
Kunrath et al. (2011)	11	Population study after major rail accident	Impact of media reporting	Two control periods compared with study period	Widespread reporting led to 44% increase in rail suicide over two months
Law et al. (2010)	12	Retrospective study of suicide cases	Impact of psychiatric contact	Cases with psychiatric diagnosis compared with no clinical contact in all forms of suicide	Non-contact group hard to reach by existing programmes and methods
Matsubayashi et al. (2013)	13	Suicides at Japanese stations	Installation of calming blue lights	Comparison of 71 stations over period 2000 and 2010	Reduction of rail suicide at 11 stations by 84%
Niederkrontententhaler, et al. (2012)	14	Population study in Vienna 1979-2009	Prevention intervention	Hotspot characteristics	Crowded nature of stations, use by at risk groups (drug users)

Pirkis et al. (2013)	15	Literature review of suicide by jumping at known hotspots	Assess the impact of structural interventions at hotspots	Meta-analysis pooling data from nine studies	The reduction in deaths from jumping following preventative measures is greater than any increases at neighbouring sites
Reynders et al. (2011)	16	Suicide databases of 15 European nations	Assessment of the accuracy of national suicide data	Comparison between data from European Railway Agency and national suicide statistics	Rail suicides are under-estimated on some national databases. ERA data more reliable
Silla and Kallberg (2012)	17	Review of Finish railway safety from 1959 to 2008	Analysis of mortality data	Rail fatalities assessed against safety measures	Overall reduction though lower in relation to deaths on open tracks because of restricted opportunities for safety measures
Thomas et al. (2013)	18	Population statistics of suicide in England and Wales	Analysis of changing methods of suicide	Comparison between 1901-07 and 2001-07	General level of railway suicide similar but increase in the proportion by females
Yang et al. (2013)	19	Longer term population study of suicide rates	Impact of media reporting over an extended period	All suicides in Taiwan between 2003-10 correlated with media reports of suicide	Delayed effect of copycat suicide following media reports of minor suicide events
Yip et al. (2012)	20	All means of suicide and the impact of preventative measures	Prevention measures	Literature review	No evidence substitution after preventative measures. Use of media methods of suicide

3. RESULTS

Table 1 summarises study characteristics and findings. Of the 20 publications identified, nine included epidemiological data on characteristics associated with railway suicides, ten addressed preventive interventions, and two included the effects on survivors and witnesses.

3.1 Epidemiology of railway suicides

O'Donnell and Farmer (1994) conducted an analysis of 3,240 cases of suicide on the London Underground between 1940 and 1990 and concluded that most cases were male (64%) with a mean age of 40.7 for men and 41.3 for females. However, subsequent studies, conducted throughout Western Europe and North America, suggest no standard demographic pattern apart from a slight dominance of males over females (Andriessen and Krysinska, 2011; Niederkrontententhaler, et al., 2012). These findings contrast with recent confidential evidence presented by BTP that indicates elevated rates in south Asian women at some London hotspots. However, this data may simply reflect the composition of the background population in these areas. This trend warrants a more detailed investigation of whether vulnerabilities due to cultural factors, gender, age, and location interact with other risk factors.

Erazo et al. (2005) explored the characteristics of those who survived railway suicide attempts from an analysis of 5,731 suicide victims recorded on the German central railway registry of accidents covering the period 1997 to 2002. They found that only 10% survived. Suicide attempts on the open track were three times more likely than attempts made at stations and women were twice as likely to survive as men. Fast-track lines and nighttime were also correlated with higher mortality.

3.2 Risk factors for rail suicide

In November 2009, Robert Enke, an international goalkeeper, committed suicide by standing in front of an express train. His celebrity status ensured that the event caught widespread media attention throughout Germany. Hegerl et al. (2013) found that the incidence of railway suicides in the two-year period following this event had increased by 18.8%, compared with the two years before Enke's suicide, (95% confidence interval (CI) = 11.0–27.1%; $p<0.001$). The median number of suicidal acts per day increased from two to three ($p<0.001$). This effect remained significant after excluding the short-term, two-week effects of Enke's suicide. An anniversary effect was not found. The increase in fatal railway suicides between 2007 and 2010 (25%) was significantly higher than the rise in the total number of suicides in Germany (6.6%) over the same period.

Although O'Donnell and Farmer (1994) reported a spring maximum, they found no evidence for a significant seasonal variation in suicide on the London Underground. A mild effect has been observed for an increase during April and another during September for males; December had the lowest number of suicides (Erazo et al., 2004). No seasonal variation was found in a study of suicide on the Munich subway between 1980 and 1999 (Ladwig et al. 2004). Using suicide data aggregated from a number of European countries, Ajdacic-Gross et al. (2010) found any seasonal effect was diminishing. However, they did not study railway suicides in particular and these many not follow the trend for other methods.

Van Houwelingen and Beersma (2001) explored whether variations in the timing of railway suicides suggested that a circadian rhythm, or biological clock, might be implicated. Researching a fifteen-year period in the Netherlands, they found that 'suicide rates at night drop to about 10% of their daytime values and that there are two daily peaks in the patterns which shift their timing over the year, with one peak occurring shortly after sunset, and the other one consistently occurring 9 to 10 hours earlier; both peaks shift with the shift in sunset time' (van Houwelingen and Beersma, 2001). Similarly Erazo et al. (2004) in a study conducted in Germany, Austria and the Netherlands reported a bimodal pattern: a morning peak between 9 am and 12 pm (14.5% of suicides) and an evening peak between 6 pm and 9 pm (16.5%). By contrast, Mishara (2007) founds that suicides peaked 1.5 to 3 hours after sunset for males and 7 to 8 hours before sunset for females. These peaks may be related to practical considerations such as lack of supervisory staff or the accessibility of railway tracks. Alternatively, they may refer to the nature of those who commit suicide. Feelings of social isolation may be reinforced at such times of the day or they may correspond to periods when symptoms become worse.

A study of the Vienna subway between 1979 and 2009 found that high rates of suicide and suicide attempts were correlated with stations that were particularly crowded and served by faster trains, those travelling at 50 mph rather than the slower tram-like stock (Niederkrontententhaler, et al (2012). These were also stations that attracted high-risk groups, notably drug users, who used them as meeting points.

Huisman, van Houwelingen and Kerkhof (2010) examined the relationship between psychiatric illness and suicide method. They found that in-patients and those with bipolar affective disorder were more likely to jump in front of a train (perceived as a sudden death) than hang themselves (perceived as slower strangulation). Acute illness and impulsivity may be factors here, irrespective of diagnosis. A significant limitation highlighted by this study, one that is shared by the majority of quantitative studies in this review, was the difficulty in conducting research into the sequence of psychological steps that led to this behaviour.

An interesting feature of the study by Huisman et al (2010) was the manner in which the study results were interpreted to support future interventions. As with other studies, (such as Hepp et al., 2012; Law, Wong and Yip, 2010; Kposowa and D'Auria, 2010), the validity of the data may have been overstated to overcome inherent methodological limitations and to offer a sufficiently robust conclusion to provide practical solutions as clarity is needed as a foundation for policy, yet research findings do not always offer clarity. The existing body of evidence is somewhat nuanced and requires careful analysis to distinguish data capable of supporting policy decisions from recommendations by the research team. Nevertheless, the tendency to make premature judgments about prevention has highlighted opportunities for further research and pilot studies.

Hepp et al. (2012) examined the prevalence of suicide among children and adolescents aged 0–19 years. They found that hanging, jumping from heights and railway suicides were the most common methods. As this is the only study within this review to focus solely on this age group, further studies may be warranted. Hepp et al., (2012) suggest that 'mental disorders might play a less crucial role in adolescent suicidal behaviour' than in adults on the grounds that they have reduced access to illicit substances and are less impacted by financial difficulties.

Law et al. (2010) examined the relationship between suicide and psychiatric care. Medical records were assessed for psychiatric service contact in a sample of 15 to 59 year olds who had committed suicide. Four factors were significantly associated with suicides of people who had no contact with psychiatric services: non-psychotic disorders such as depression and anxiety (OR = 13.5, 95% CI: 2.9-62.9), unmanageable debts (OR = 10.5, CI: 2.4-45.3), being fully or partially self-employed at the time of death (OR = 10.0, CI: 1.6-64.1) and having higher levels of social problem-solving ability (SPSI) (OR = 2.0, CI: 1.1-3.6). The group that had not contacted psychiatric services comprised a larger proportion of the suicide population in this study. An important implication is that non-clinical establishments that include people and groups not considered to be at high risk, for example, schools and workplaces, may need to participate in a united and collaborative approach to successfully prevent suicide on railways. Although this research suggests that most people who commit suicide have had no contact with psychiatric services, it does not invalidate the finding that those patients who have been admitted to hospital with schizophrenia and depression are at significant risk of suicide (Delaney et al., 2012).

Mitchell et al. (2009) argued that interventions should draw on information provided by the survivors of suicide, and also carers and family of those who have lost a relative as a result of a successful suicide. There are relatively few psychological post-mortem studies that assess the impact of suicides on surviving family members (Tzeng, 2010). Sun et al., (in press), who evaluated an education programme for family members of suicidal subjects, found that participation in this programme improved help seeking, whilst 'caring ability' was also significantly improved after one year. This study provides substance to the claim that family members could play a part in devising an effective intervention to reduce suicides on railways.

3.3 Preventative Measures

3.3.1 Physical interventions

During the 1990s, following a major conference and series of investigations, London Underground Ltd (LUL) introduced a range of preventative measures. These were designed to prevent or limit access to tunnels and tracks, together with measures to 'encourage hesitation', in today's terms to reduce impulsivity. It had been found that 85% to 90% of suicides occurred on platforms and of these two-thirds had stood in the first third of the platform where the incoming train was at its greatest speed (Clarke and Poyner, 1994). As

a result, platform-edge barriers were constructed at new stations on the Jubilee Line, whilst gates to prevent passengers from entering tunnels were installed at existing stations. Visible markings and warning signs were designed to keep people away from platform edges, while CCTV systems were installed to monitor numbers and prevent over-crowding.

A number of studies have shown that physical barriers reduce the number of train suicides (Mishara, 2007; Ladwig et al., 2009; Baumert et al., 2011). Platform screen doors are highly effective (Law et al., 2006), though they are expensive to install and are limited, in the main, to stations constructed in tunnels. Similarly, a study of the New York subway fatalities between 1990 and 2003 concluded that the most effective measures were those that focused on the structure of the network, notably barriers and environmental controls (Gershon et al., 2008).

In deep tunnel stations on the London Underground a one-metre pit was constructed between the tracks to drain water. Although not designed for this purpose, these 'suicide pits' were found to reduce the mortality rate of people who jumped or fell in front of an on-coming train. A study conducted between January 1996 and March 1997 found that of 58 passengers who jumped or fell on to tracks found that 33 (57%) were killed (Coats and Walter, 1999). Mortality rates at stations without pits (76%) were significantly higher than those with them (44%).

Yip et al., (2012) argue that if access to a method of suicide is restricted, then individuals do not seek a more effective substitute. For example, Thomas et al., (2011) showed that the number of fatal carbon monoxide poisonings in the UK rose in the early 1980s, but fell after the introduction of catalytic converters to car exhaust systems. The key finding is that the number of suicides is related, in part, to availability of lethal methods. This finding is also reflected in the fact that the four occupations in the UK with the highest suicide rates include doctors, dentists and veterinary surgeons, all of whom have ready access to methods of self-harm.

A ten-year follow-up study of 94 persons who had survived a suicide attempt by jumping in front of a London Underground train, found that only three attempted this method a second time (O'Donnell et al., 1994). A systematic literature review of interventions designed to reduce suicides at hotspots (Cox et al., 2013) found that restricting access to means (through the installation of physical barriers) was the most effective method. The study also discovered relatively strong evidence that reducing access to means can avert suicides without substitution effects. Pirkis et al. (2013) in a meta-analysis of suicide hotspots found that the reduction in deaths following the installation of preventative measures did lead to small increases at neighbouring sites. However, in this study not limited to railways, there was an overall reduction in suicides by jumping.

3.3.2 Psychological interventions

A study that reviewed strategies designed to restrict the opportunities for suicide concluded that interventions designed to address suicidal thought processes could be as effective as restricting access to the means of suicide, particularly where the method is less likely to be substituted (Florentine and Crane, 2010). They recommend that practical initiatives be provided in conjunction with psychosocial interventions as part of an inclusive suicide prevention strategy. Psychosocial preventative measures can 'intervene at earlier stages, helping individuals cope with negative life events and relieve distress that might otherwise result in suicidal ideation' (p. 1627). This requires a personal strategy, which takes account of individual narratives, cognitive styles of coping with emotional strain, and an understanding about how sources of help and care are overlooking or accommodating of maladaptive coping that risks suicide as an outcome. In addition, Florentine and Crane argued that 'restricting physical availability of suicide methods could have the potential to disrupt the transition from ideation to a suicide attempt and the probability that a suicide attempt will lead to death by suicide depending on the lethality of the method restricted' (p. 1627).

It is important to identify features of station design and organisation that may restrict or delay impulsive behaviour. In addition, it has been shown that public concern about potential victims may be helpful, as well as practical measures already in place like barriers (Law et al., 2009; Sinyor and Levitt, 2010; Mohl et al., 2012), and boundary lines for platform waiting areas.
In their study of railway safety in Finland, Silla and Kallberg (2012) identified level crossings as sites of high risk and recommended replacing them wherever practically possible, together with a community safety programme designed to reduce incidents of railway trespass.

In Japan a significant rise in railway suicides (from 534 in 2006 to 682 in 2009) led to the installation of blue light-emitting-diode (LED) lamps on railway platforms and at railway crossings as a means of deterring suicides. Blue is reported to have soothing psychological properties. A comparison between eleven stations with the blue lights and 60 without the intervention suggested that they reduced the suicide rate by 84%. It is hypothesised that blue lights inhibit suicidal impulses by providing a calming environment (Matsubayashi, Sawada and Ueda, 2013). However, this remains the only study of its kind and the effect has not been replicated or established over the long-term. Other literature suggests that once a person has crossed the 'decision-line' it will require much more than a barrier (Sinyor and Levitt, 2010) or a blue light to stop them. The blue light phenomenon requires further investigation to discover not only its impact but also its mechanism.

3.3.3 Broadcast and information interventions

The literature has explored the extent to which the reporting of suicide in the media can encourage copycat acts, the so-called Werther effect (Holdaway, 2010). The widespread reporting of suicide, including those on the railways, may increase the number of incidents. A study conducted in Germany explored the impact on the rate of railway suicides of an

exceptionally dramatic incident in which three people were killed on a railway line (Kunrath et al., 2011). The authors found that widespread media coverage of this event led to a 44% increase in railway suicides during the two months after the publicised event. The peak increase occurred within a week of the event with a daily maximum of eight railway suicides. Yang et al. (2013) sought to explore the long-term effect of media reports of minor suicide effects. Recording 31,364 suicides in Taiwan over the period 2003 to 2010, they discovered a delayed effect of copycat suicide and concluded that reporting of minor suicide events should be avoided. As a result, it may be advisable to speak of a 'passenger incident', rather than report that 'there is a person under a train'. The systematic literature review of hotspots by Cox et al. (2013) also suggested that responsible media reporting could reduce the number of copycat suicides. Yip et al. (2012) also argued that information derived from formal and informal media affects the choices that people make about which methods to use when attempting suicide. From semi-structured interviews of individuals who had survived a near-fatal suicide attempt, Biddle et al. (2012) found that they had used the Internet and media as sources of information. The authors concluded that the media could be used for prevention through carefully crafted portrayals of suicide designed to generate negative social perceptions of popular methods.

Currently, it is unclear whether information about the prevalence and effects of railway suicides on individuals, their families and witnesses has a role as a deterrent. Meanwhile, the literature suggests that clinical risk assessments of suicide are not particularly effective (Fowler, 2012). A public health campaign may have a dual role to play in simultaneously raising public awareness of mental health concerns, while also reducing the possibility of copycat suicides.

4. CONCLUSIONS AND IMPLICATIONS: POLICY, PRACTICE AND RESEARCH

Much research has been conducted throughout Europe into suicide on the railways over the last twenty years. However, it has revealed national differences and the need for studies that take account of cultural factors and the particular circumstances of individual railway systems. The key findings are that preventative measures are effective and do not result in the substitution of other methods that cancel out reductions in suicide rates. Physical barriers, the replacement of level crossings, and suicide pits have been shown to be particularly effective in reducing deaths. However, most low-cost measures have probably already been introduced. Further physical interventions are likely to be expensive: platform-edge barriers, the removal of level crossings and high-level fencing over long distances. There remains scope for cost-effective, psychological interventions that reduce impulsivity and controls over the flow of information about rail suicide are also important.

The review suggests that there are areas for intervention to reduce the incidence of train suicide, and there are several areas for practice development, new policy and research.

- Address the thought processes that drive suicidal behaviour, a person-centred and individual life-course approach is needed, including psychosocial and behavioural and social interventions in all high-risk populations. Further research to design programmes that inhibit impulsivity would be of value. These should take account of personal narratives and solutions, as well as social networks and supports that might be part of a preventive intervention.

- This approach also requires public health agencies like local government, Health and Wellbeing boards, commissioners of health and social care services, and providers of health and social care services to all work more closely with other agencies. This should include specific assessments of suicide risk, particularly if patients and services are located near railway hubs.

- Primary care, particularly GP services, are often where people in distress present first, and in the population that commit suicide outwith the transport related population, seventy-eight percent of those patients have seen their primary care professional in the previous month. NHS England are supporting a review of directly commissioned primary care services, as well as a review of the services commissioned by local Clinical Commissioning Groups. It is imperative that self-harm and suicide prevention are included in this work so that primary care emergency response can be strengthened and supported by response from specialist mental health services.

- The access to, and role of crisis teams, assertive outreach teams and emergency responses, as well as the care of those known to be at risk of railway suicide needs review; service commissioners should consider specifying the role of crisis teams in

providing embedded and highly skilled link workers to work in transport hubs and with the local police.

- Specific standards of risk and safety assessment in professional practice, and a clear clinical pathway to promote safety are needed, alongside clinical leadership to ensure preventive efforts are optimized. Professional bodies including the Royal Colleges and The National Institute for Clinical Excellence may be best placed to advise commissioners and to support implementation and evaluation of those standards.

- Although the literature has established an association between rail suicide and psychiatric illness, suggesting that patients with psychological disorders are over-represented, this requires further research. The link between the location of psychiatric units and hotspot stations is unclear.

- Currently, little is known about the socio-economic status and ethnicity of those who commit suicide on the UK railway system. Greater understanding of the population at risk of these acts will inform effective preventative strategies.

- Public health experts and local government could consider how best to address the causal factors in a proportion of suicides in their communities where mental illness is not present. For example, given the relationship to social, cultural, employment and financial stressors, public health experts may be able to assist with local strategies to promote psychologically healthy employment work places and to put in place services to support those with debt.

- Community leaders in areas where there appear to be higher rates of suicide may want to consider, with local public health experts, interventions that assist those in distress or facing social and financial strain. Local safeguarding Board may also want to consider reviewing suicides locally

- Address the public reporting of suicide from journalistic and social media sources. A review is proposed of guidelines about public reporting of suicide. The guidance should address reporting and announcing suicide at railways, underground stations, and in the press and media and standards of performance.

- Remove or neutralise sensory cues to impulsivity, and create a more calming environment. There is initial evidence from Japan that blue lights at suicide hotspots (stations and railway crossings) reduce the number of attempts and death. However, it is a single study and the effect has yet to be replicated. If this mechanism can be verified, there may be other opportunities to introduce calming measures. Currently, for example, the fronts of Underground trains are painted red, often perceived as a demanding or aggressive colour, and associated with blood. A calmer colour (such as green or blue) may be less likely to trigger impulsive and self-destructive acts.

- There is some evidence that overcrowding may encourage impulsive behaviour and that the high level of suicides at busy stations is not simply a reflection of numbers but also an effect of crowding. Crowding can also hide suspicious behaviours or other signs of vulnerability.

- Ensure stations have a culture of safety and care signaled to all passengers through health messaging, posters, contact details for crises, and perhaps co-location of other health and wellbeing providers, may all transform the environment to mitigate impulsivity. Encouraging passengers to have a culture of vigilance and public sanction to notify staff of concerns is important in any case. Video feedback to passengers waiting on the platform of may also offer visual clues about vulnerable adults. Make the concern about suicides on the transport system a legitimate public health and wellbeing issue, for public health agencies, commissioning groups, and transport providers to openly debate and address as a necessary part of an overall response. This could also be an opportunity to deliver other health and safety messages, for public mental and physical health outcomes, so offering other benefits, and also creating a structured health and safety focused environment.

- Physical barriers and pits are known to be helpful, and should be considered in all future design; the costs of physical barriers may be substantial but a full economic analysis is required as the cost of no action is also substantial.

- The evidence is not compelling for new interventions in the absence of evaluation and economic impacts. Therefore, intervention studies are required of patients at risk of suicide close to transport hubs that are known to be hotspots. This may help clarify which are the most promising and cost-effective interventions. Focusing on high-risk groups seems the most effective and economic approach to take, and innovative methods of assessing multiple interventions in a real-world design for rapid review and screening of effects (for example, fractional factorial designs) may be one option, whilst trials and natural experiments another. The risk of adopting interventions without sufficient evidence is one of promoting false hope, as well unexpected adverse outcomes.

- A national confidential inquiry process and reporting system would enable the monitoring of trends countrywide, comparison with population suicide data, and evaluation of interventions to improve outcomes.

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