



Interventions to reduce suicides at suicide hotspots: a systematic review and meta-analysis

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Summary

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Background Various interventions have been introduced to try to prevent suicides at suicide hotspots, but evidence of their effectiveness needs to be strengthened.

Methods We did a systematic search of Medline, PsycINFO, and Scopus for studies of interventions, delivered in combination with others or in isolation, to prevent suicide at suicide hotspots. We did a meta-analysis to assess the effect of interventions that restrict access to means, encourage help-seeking, or increase the likelihood of intervention by a third party.

Findings We identified 23 articles representing 18 unique studies. After we removed one outlier, interventions that restricted access to means were associated with a reduction in the number of suicides per year (incidence rate ratio 0.09, 95% CI 0.03–0.27; $p < 0.0001$), as were interventions that encourage help-seeking (0.49, 95% CI 0.29–0.83; $p = 0.0086$), and interventions that increase the likelihood of intervention by a third party (0.53, 95% CI 0.31–0.89; $p = 0.0155$). When we included only those studies that assessed a particular intervention in isolation, restricting access to means was associated with a reduction in the risk of suicide (0.07, 95% CI 0.02–0.19; $p < 0.0001$), as was encouraging help-seeking (0.39, 95% CI 0.19–0.80; $p = 0.0101$); no studies assessed increasing the likelihood of intervention by a third party as a lone intervention.

Interpretation The key approaches that are currently used as interventions at suicide hotspots seem to be effective. Priority should be given to ongoing implementation and assessment of initiatives at suicide hotspots, not only to prevent so-called copycat events, but also because of the effect that suicides at these sites have on people who work at them, live near them, or frequent them for other reasons.

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Introduction

Suicide hotspots are specific, accessible, and usually public sites which are frequently used as locations for suicide and gain reputations as such.¹ Some hotspots offer the means of suicide, usually by jumping. Others offer seclusion, making it unlikely that a suicide attempt will be interrupted and increasing the chance that it will be fatal. In metropolitan areas, suicide hotspots tend to be bridges, tall buildings, car parks, and railway tracks. In less built-up areas, they are more likely to take the form of cliffs and woodland areas. Word-of-mouth and media reports can perpetuate the reputations of these sites as suicide hotspots, creating a form of contagion whereby individuals are drawn to these sites because they have heard that others have gone there to attempt suicide.¹

Various interventions have been introduced to try to prevent suicides at suicide hotspots. In 2013, members of our team and others² systematically reviewed studies assessing the effectiveness of these interventions, and classified them into four general approaches: (1) restricting access to means, (2) encouraging help-seeking, (3) increasing the likelihood of intervention by a third party, and (4) encouraging responsible media reporting of suicide. Most studies concerned restricting access to means, particularly barriers on bridges and cliffs. Our

team and colleagues³ pooled data from studies assessing the effectiveness of restricting access to means in a meta-analysis and concluded that there was unequivocal evidence that this approach can avert suicides at these sites.³ The evidence for other approaches was weaker.²

When strategies are implemented to prevent suicides at hotspots, several interventions are often used simultaneously. This occurred at Gap Park in Sydney, for example,⁴ where community and industry partners instituted a programme in the area surrounding cliffs, which involved restricting access to means (constructing a new inwardly curved fence along the cliff's edge), encouraging help-seeking (installing telephones that linked directly to Australia's largest crisis service, Lifeline; putting up signs that displayed positive messages and Lifeline's telephone number), increasing the likelihood of intervention by a third party (installing CCTV cameras; improving the amenity of the site), and encouraging responsible reporting of suicide at the site (working closely with local media to prepare stories that were consistent with Australia's media guidelines).⁴

These sorts of multifaceted intervention make sense given the evidence of their effectiveness.^{2,3} However, if the evidence could be strengthened, and the independent contributions of these different interventions better quantified, then these approaches might be further

refined. In particular, it would be useful to know the relative effectiveness of each of the interventions (delivered in isolation or in association with other interventions). To meet this need, we did a meta-analysis of the effect of interventions on suicide rates at suicide hotspots.

Methods

Study design and procedures

We searched Medline, PsycINFO, and Scopus from their inception to April 21, 2015 for the following terms, mapped onto MeSH headings where applicable: (suicid* OR hotspot) AND (cliff OR building OR high-rise OR multi-storey OR viaduct OR rail OR metro OR subway OR river OR lake OR sea OR public* OR secluded OR remote OR woods OR forest OR rural OR magnet OR location OR bridge OR skyscraper OR car park OR underground OR road OR motorway OR highway OR reservoir OR coast OR jump* OR leap* OR fall OR height OR lie OR lying OR moving object OR carbon monoxide OR car exhaust OR hang* OR firearm OR gun* OR burn* OR drown* OR fenc* OR barrier* OR parapet OR net* OR pit* OR sign* OR poster* OR helpline* OR surveillance* OR CCTV OR patrol* OR media OR reporting OR television OR radio). We also searched references and citations of the found studies and of key reviews of the subject. We included only English-language publications.

We restricted our meta-analysis to research studies published in scientific journals and excluded other publications (eg, reviews, commentaries, editorials, conference proceedings, working papers, and reports). The studies had to assess an intervention (or several interventions) at a suicide hotspot, providing pre-intervention and post-intervention data. They also had to use completed suicide as the primary outcome variable. Collectively, studies had to present data for a given intervention in a manner that could be pooled within

intervention types. This meant that for interventions that were assessed by only a single study, the study could not be included in the meta-analysis (and therefore the relative effectiveness of the intervention could not be assessed).

We constructed a dataset in which each study was represented by two rows, one for the pre-intervention period and the other for the post-intervention period. For each study, we extracted data about the observation period (in years) and the number of suicides in that period. We also extracted information on the type of intervention. We extracted data directly from the articles related to each study, seeking additional information from the authors in three instances.⁵⁻⁸ We also updated the data from a case study done by members of our team.⁴

Statistical analysis

For each group of studies, we estimated the pooled incidence rate ratio (IRR) with a random-effects conditional model with an exact likelihood function.⁹ This model is essentially a mixed-effects Poisson regression model in which observations are grouped within studies. The model estimates the population averaged change in the incidence (ie, the pooled IRR) from the pre-intervention period to the post-intervention period, accounting for between-study differences. Because the model is based on the Poisson distribution, it naturally accounts for the fact that studies had different exposure times by including observation periods as an offset term in the analysis. It also caters for the fact that many studies showed a reduction in suicides to zero after the intervention was introduced.¹⁰

To estimate the effect of each intervention, we planned to fit six models to the data, two for each type of intervention (one in which we included all studies in which the intervention had been introduced either in

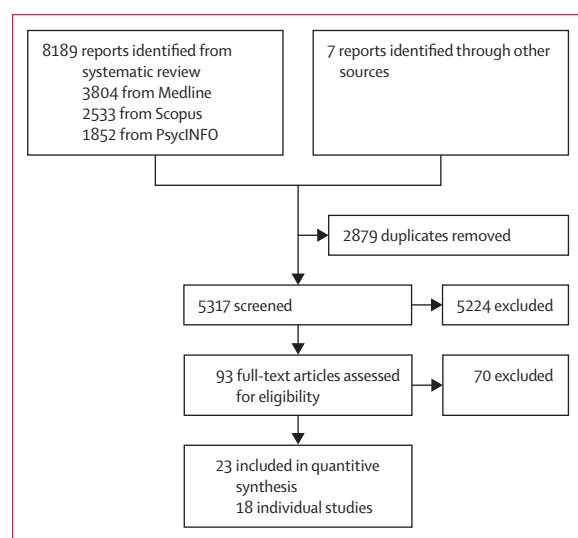


Figure 1: Study selection

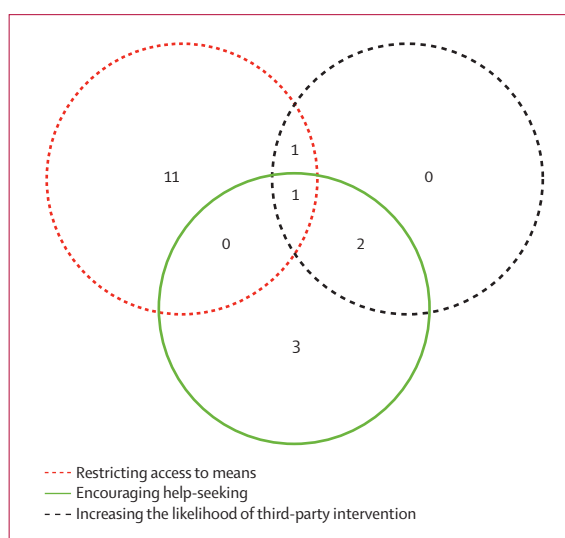


Figure 2: Combinations of interventions assessed in included studies

	Hotspot site	Suicide method typically used at site	Intervention type		
			Restricting access to means	Encouraging help-seeking	Increasing the likelihood of intervention by a third party
Beautrais (2001); ¹² Beautrais et al (2009) ¹³	Grafton Bridge, Auckland, New Zealand	Jumping from height	Installation of a glass barrier in 2003, replacing one removed in 1996	..	..
Bennewith et al (2007); ¹⁴ Bennewith et al (2011) ¹⁵	Clifton Suspension Bridge, Bristol, UK	Jumping from height	Installation of 2-m high wire fencing on main span in 1998	..	Expansion of role of bridge staff to include ensuring individuals' safety and monitoring incidents; CCTV cameras installed
Glatt et al (1986); ¹⁷ Glatt (1987) ¹⁶	Mid-Hutson Bridge, Poughkeepsie, NY, USA	Jumping from height	..	Installation of signs directing troubled individuals to call the local 24-h psychiatric emergency service, followed by installation of dedicated crisis telephones in late August 1984	..
Isaac and Bennett ²⁸	Beachy Head, Sussex, UK	Jumping from height	Road access blocked from January to June 2001 because of outbreak of foot and mouth disease.	..	..
King and Frost (2005) ¹⁸	New Forest, Hampshire, UK	Carbon monoxide poisoning (by car exhaust in isolated car parks)	..	Installation of signs displaying Samaritans' national telephone number in 26 car parks in 1998	..
Law et al (2009); ⁸ Law and Yip (2011) ⁷	Underground railway system, Hong Kong	Jumping in front of moving object	Installation of platform screen doors on 71 platforms in 30 underground stations on three prominent transit lines; work began in 2002, and ended in 2005, but most of the busiest station platforms were sealed in the first year	..	..
Law et al (2014) ¹⁹	Gateway Bridge, Brisbane, Australia	Jumping from height	Installation of 3.3-m high barriers in 1993; replaced with 3.6-m barriers in November 2010	..	..
Lester (1993); ²⁷ O'Carroll and Silverman (1994) ⁵	Ellington Bridge, Washington DC, USA	Jumping from height	Installation of 2.4-m high fence in late January 1986	..	..
Lester (2005) ²⁰	Sunshine Skyway Bridge, St Petersburg, FL, USA	Jumping from height	..	Installation of crisis emergency telephones in July 1999	Establishment of police presence on the bridge in 2000
Lockley et al (2014) ⁴	Gap Park, Sydney, Australia	Jumping from height	Installation of 1.3-m high fencing along clifftop in July 2011	Installation of crisis telephones and signs displaying a dedicated lifeline telephone number in February 2010	Installation of CCTV cameras in February 2010
Mohl et al (2012) ²¹	The Cantonal Hospital, Baden, Switzerland	Jumping from height	Installation of a guard rail at each of the 1240 hospital windows, 18 cm above the window sill, starting in June 2004	..	..
Pelletier (2007) ²²	Memorial Bridge, Augusta, ME, USA	Jumping from height	Installation of 3.4-m high fence on either side of bridge in 1983	..	..
Perron et al (2013) ²³	Jacques-Cartier Bridge, Montreal, QC, Canada	Jumping from height	Extension of existing 1.1 m fence by a further 1.4 m with inwardly curving top in 2004	..	..
Reisch and Michel (2005) ⁶	Muenster Terrace, Bern, Switzerland	Jumping from height	Installation of 4-m wide wire mesh net, 7 m below top of terrace in December 1998	..	..
Sinyor and Levitt (2010) ²⁴	Bloor Street Viaduct, Toronto, ON, Canada	Jumping from height	Construction of 5-m high barrier between April 2002, and June 2003	..	..
Skegg and Herbison (2009) ²⁵	Lawyers Head Cliff, Dunedin, New Zealand	Jumping from height	Blocking of road access for maintenance in 2006	..	..
Stack (2015) ²⁹	Skyway Bridge, St Petersburg, FL, USA	Jumping from height	..	Installation of six crisis telephones on the bridge in July 1999	..
Wong et al (2009) ²⁶	Cheung Chau, Hong Kong	Carbon monoxide poisoning (by charcoal burning in rented holiday flats)	..	Establishment of integrative suicide prevention programme in October 2002, which included telephone hotlines	Gatekeeper training and police patrols

Table 1: Interventions assessed in included studies

	Intervention type	Duration of observation period (years)		Total suicides		Suicides per year	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Beautrais (2001); Beautrais et al (2009)	Restricting access to means	6.0	4.0	19	0	3.2	0.0
Bennewith et al (2007); Bennewith et al (2011)	Restricting access to means; increasing the likelihood of intervention by a third party	5.0	5.0	41	20	8.2	4.0
Glatt et al (1986); Glatt (1987)	Encouraging help-seeking	1.0	2.2	5	5	5.0	2.3
Isaac and Bennett (2005)	Restricting access to means	14.0	0.4	221	0	15.8	0.0
King and Frost (2005)	Encouraging help-seeking	10.0	3.0	47	5	4.7	1.7
Law et al (2009); Law and Yip (2011)	Restricting access to means	5.0	5.0	29	3	5.8	0.6
Law et al (2014)	Restricting access to means	4.0	19.0	22	16	5.5	0.8
Lester (1993); O'Carroll and Silverman (1994)	Restricting access to means	7.0	5.0	25	1	3.6	0.2
Lester (2005)	Encouraging help-seeking; increasing the likelihood of intervention by a third party	3.0	3.0	25	19	8.3	6.3
Lockley et al (2014)	Restricting access to means; encouraging help-seeking Increasing the likelihood of intervention by a third party	10.6	2.4	79	16	7.5	6.7
Mohl et al (2012)	Restricting access to means	9.5	6.5	10	1	1.1	0.2
Pelletier (2007)	Restricting access to means	22.0	2.0	14	0	0.6	0.0
Perron et al (2013)	Restricting access to means	13.5	5.0	135	13	10.0	2.6
Reisch and Michel (2005)	Restricting access to means	3.0	3.0	7	0	2.3	0.0
Sinyor and Levitt (2010)	Restricting access to means	9.0	4.0	86	0	9.6	0.0
Skegg and Herbison (2009)	Restricting access to means	10.0	2.0	13	0	1.3	0.0
Stack (2015)	Encouraging help-seeking	13.0	13.0	48	106	3.7	8.2
Wong et al (2009)	Encouraging help-seeking; increasing the likelihood of intervention by a third party	4.25	3.5	37	6	8.7	1.7
Total	..	149.85	88.0	863	221	5.8	2.4

Table 2: Pre-intervention and post-intervention suicide rates for individual studies

isolation or in combination with other interventions, and the other in which we included only those studies in which the intervention had been introduced in isolation). To set up each model, we regressed the number of deaths on a variable distinguishing the pre-intervention periods from the post-intervention periods for the intervention of interest. In all analyses, we included an offset term for exposure time. The effect size for the pre-intervention versus post-intervention dummy variable was interpreted as the pooled IRR—ie, the change in the expected number of suicides per year after the introduction of the intervention of interest. Our models included estimates of between-study heterogeneity, which are reported as the I^2 statistic.¹¹

Results

We initially identified 8196 articles (figure 1). Removal of duplicates and screening titles and abstracts left 93 full-text articles, 70 of which we excluded, mostly because they did not relate to suicide hotspots or did not present pre-intervention and post-intervention data on suicides. We included the remaining 23 articles in the meta-analysis.^{4-8,12-29} We treated articles about the same intervention at the same site as being about the same study (even when the authors were not the same) because

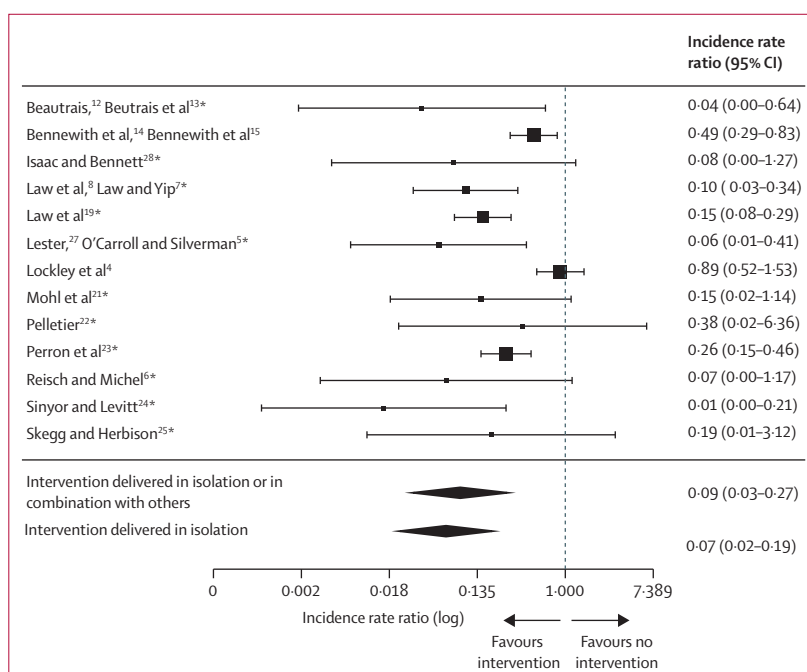


Figure 3: Risk of suicide after introducing interventions to restrict access to means

*Considered intervention in isolation.

they used the same data, on the basis that treating them as separate would have been double-counting. Using this logic, the 23 articles represented 18 unique studies.

We found one study of the value of encouraging responsible reporting of suicide at a hotspot.^{30–33} We identified another single study of an intervention that did not fit into our pre-defined classification—installation of blue lights at a hotspot to create a calming atmosphere.^{34,35} Because they were single studies of given interventions, neither could be included in the meta-analysis.

13 studies assessed restricting access to means (11 in isolation, two in combination with other interventions), six assessed encouraging help-seeking (three in isolation, three in combination with other interventions), and four assessed increasing the likelihood of intervention by a third party (all in combination with other interventions; figure 2, table 1).

The pre-intervention periods range from 1.0 years to 22.0 years, and the post-intervention periods range from 0.4 years to 19.0 years (table 2). For studies with post-intervention periods of less than 2 years we contacted the authors and updated the data wherever possible. We

were able to do this for the study of Lockley and colleagues,⁴ but not for Isaac and Bennett's study;²⁸ their intervention was not designed to reduce suicides, but rather to block road access to agricultural land during the 2001 foot and mouth outbreak in the UK. The roadblock was removed after 5 months; therefore, there was no opportunity to collect further post-intervention data.

In total, 863 deaths by suicide occurred over 149.85 study-years before the interventions were introduced (an unweighted mean of 5.8 suicides per year), and 211 deaths by suicide occurred over 88.0 study-years after the interventions were introduced (an unweighted mean of 2.4 suicides per year; table 2). In six of 18 studies, the number of suicides dropped to zero in the post-intervention period. The only study in which the yearly number of suicides did not drop—in fact it increased substantially—was that of Stack.²⁹ Stack recorded deaths by suicide at the Skyway Bridge in St Petersburg, FL, USA before and after the introduction of six crisis telephones in 1999. During the extensive post-intervention period (13 years), a website not related to the intervention became increasingly popular. This website promotes dissemination of information on suicides on the bridge, provides a forum or blog for interested parties, and contains disturbing information that might promote copycat acts. The website might have negated any potentially positive effects of the crisis telephones.²⁹

Figures 3–5 show the overall effect of each of the three interventions. For restricting access to means (figure 3) and encouraging help-seeking (figure 4), we calculated two IRRs, one using data from all studies in which the intervention was delivered (either in isolation or alongside other interventions) and one which from studies in which the intervention was introduced in isolation. For increasing the likelihood of intervention by a third party (figure 5), we could calculate only the IRR using data from all studies in which the intervention was delivered because no studies assessed this intervention in isolation.

Restricting access to means was associated with a reduction in the number of suicides per year when all 13 studies were considered (IRR 0.09, 95% CI 0.03–0.27; $p < 0.0001$), and when the analysis was restricted to the 11 studies that considered the intervention in isolation (IRR 0.07, 95% CI 0.02–0.19, $p < 0.0001$).

We did two separate analyses of studies of encouraging help-seeking, one that included the study by Stack,²⁹ and one that excluded because it was an outlier. When it was included, encouraging help-seeking was associated with no significant change in the number of suicides per year when data from all six studies were pooled (IRR 0.64, 95% CI 0.33–1.26; $p = 0.20$), and when the analysis was limited to the three studies that assessed this intervention when delivered alone (IRR 0.79, 95% CI 0.27–2.27; $p = 0.66$). When excluding the study by Stack, encouraging help-seeking was associated with a significant reduction when data from all other studies

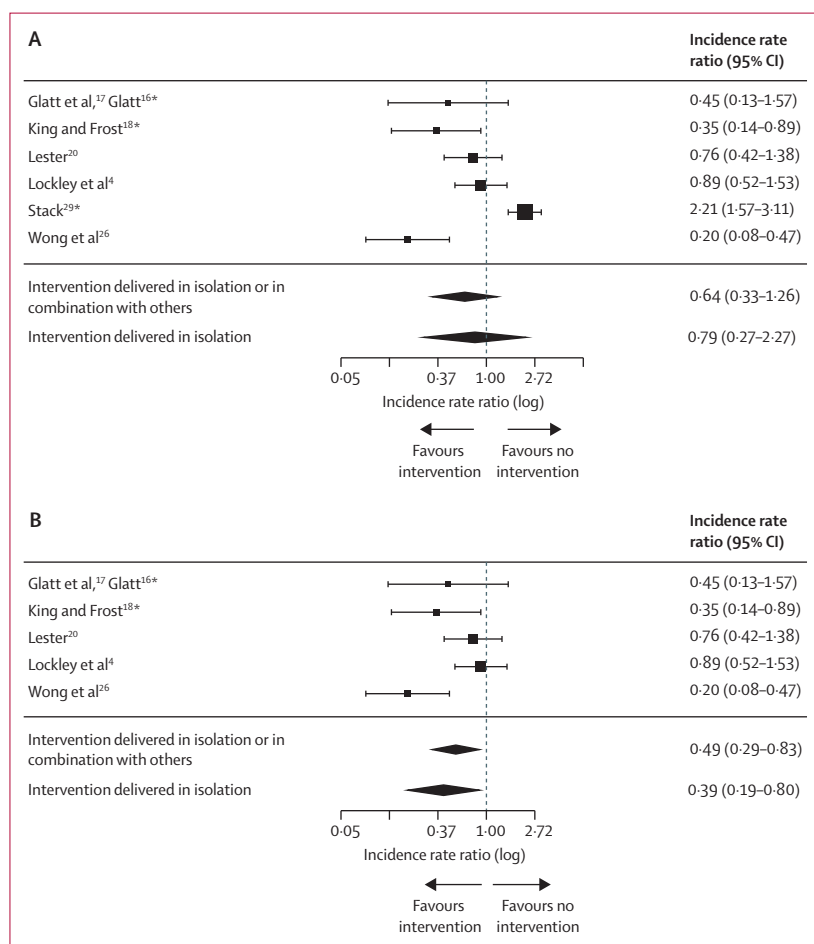


Figure 4: Risk of suicide after introducing interventions to encourage help-seeking

(A) Including the study by Stack,²⁹ and (B) excluding the study by Stack.^{29*} Considered intervention in isolation.

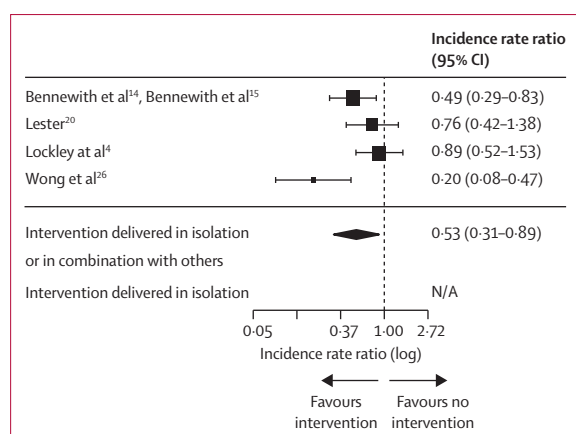


Figure 5: Risk of suicide after introducing interventions to increase the likelihood of intervention by a third party

*Considered intervention in isolation.

were included (IRR 0.49, 95% CI 0.29–0.83; $p=0.0086$), and when only including the two studies that considered the intervention in isolation (IRR 0.39, 95% CI 0.19–0.80, $p=0.0101$).

Increasing the likelihood of intervention by a third party was associated with a significant reduction in the yearly number of suicides (IRR 0.53, 95% CI 0.31–0.89; $p=0.0155$).

We detected heterogeneity in the IRRs between studies. For restricting access to means, I^2 was 86% when 13 studies were included in the analysis and 60% when restricted to the 11 studies that assessed the intervention in isolation. For analysis of encouraging help-seeking including Stack, I^2 was 84% when all six studies were included, and 80% when the analysis was limited to the three studies that assessed the intervention in isolation. For analysis of encouraging help-seeking that excluded Stack, I^2 was 57% for the initial five studies and 0% for the two studies that assessed the intervention alone. For the four studies that assessed increasing the likelihood of intervention by a third party, I^2 was 65%.

Discussion

Our meta-analysis provides evidence that restricting access to means, encouraging help-seeking, and increasing the likelihood of intervention by a third party can reduce deaths by suicide at suicide hotspots. A previous systematic review and meta-analysis done by members of our team and colleagues² and a meta-analysis³ suggested that the evidence for restricting access to means was strong, but that the evidence for the other two interventions was more equivocal. On the basis of the present findings, and notwithstanding the findings of the study by Stack on encouraging help-seeking, we argue that the evidence for encouraging help-seeking and increasing the likelihood of intervention by a third party is now also very promising.

This finding is important because restricting access to means is not always viable. Communities often oppose actions such as putting up barriers, usually for reasons of aesthetics (eg, barriers will spoil the view) and substitution (eg, people will find other sites to jump from).^{13,16} We refute these arguments. There are many examples of barriers that have been incorporated into the environment in a way that does not mar the view, and studies of substitution suggest that, although there may be some shifting of suicidal acts to other sites, deaths by the same method are still significantly reduced overall.³ We acknowledge, however, that restricting access to means might not always be feasible (eg, where the hotspot is an open railway network)³⁶ and that, even if it is, it is likely to be expensive, at least in the short term (although cost effective in the longer term).³⁷ Thus, having additional cheaper and effective options available is important. Encouraging help-seeking and increasing the likelihood of intervention by a third party both seem to be valuable strategies to reduce suicides at hotspots.

Our meta-analysis had some limitations that constrain our conclusions. Our search strategy might have missed some studies (eg, those with no abstracts or those with abstracts that did not explicitly mention suicidal behaviours at suicide hotspots), and there might have been some publication bias. Considering the specificity of the subject of investigation, we identified many studies. However, we did not identify enough to fully explore the research questions. We considered only interventions that had been the subject of more than one study, which prevented us assessing the value of encouraging responsible reporting of suicide at a hotspot and installing blue lights at a hotspot to create a calming atmosphere. A single study of whether providing guidance to journalists who might be preparing stories about suicides at a particular site (an underground railway network) showed this intervention to be useful.^{30–33} Similarly, efforts to gauge the effectiveness of installing blue lights to create a calming effect at railway stations yielded promising results,^{34,35} although further analysis suggested that the effect might not be as substantial as originally thought.³⁵

Our findings might have been different if we included attempted suicide as well as completed suicide as an outcome, although we believe that this is unlikely because of the high case fatality rate associated with the methods used at suicide hotspots. Very few studies assessed attempted suicide, and most of those that did also presented data for completed suicide (and were therefore included). We identified one study³⁸ of restricting access to means (by installing platform sliding doors on underground railway stations in Tokyo), which used incident data provided by the railway network. We had to exclude this study because we could not disaggregate completed suicides from attempted suicides, but it reported positive findings.³⁸

We were unable to assess whether particular combinations of interventions produced the best outcomes because the combinations that had been studied were not exhaustive. Increasing the likelihood of third party intervention has not been studied as a lone intervention.

Some studies might have under-described the interventions that were used, especially those that assessed restricting access to means. Constructing barriers or other impediments to jumping is a major undertaking, so if other activities (eg, putting up signs, providing instructions for relevant personnel) occurred simultaneously or subsequently they might not have attracted the same degree of attention. We know, for example, that signs encouraging help-seeking are present on the Clifton Suspension Bridge, but the study at this site made reference only to the installation of barriers and the training of bridge staff.^{14,15}

These limitations largely rest with the source data for our meta-analysis, which has implications for future research. Additional studies are needed that allow for the disaggregation of the effects of different interventions. Ideally, initiatives that involve multiple interventions should be rolled out progressively, so that the different effects of individual interventions can be assessed. In practice, we acknowledge that this is unlikely to happen; where communities are mobilised to take action at a given hotspot they are likely to implement a range of interventions simultaneously. At the very least, communities that put in place initiatives to combat suicide at suicide hotspots should be encouraged to document the processes, impacts, and outcomes of these initiatives, drawing on techniques used in the evaluation of complex programmes in unrelated areas (eg, clarifying the logic by which the programme is expected to work and testing whether it does work in this way, triangulating data from multiple sources, considering costs as well as outcomes).³⁹ More studies of different combinations of interventions would provide further insights into the best way of delivering these interventions.

Offered together, these interventions have the potential to complement each other. Restricting access to means, for example, is thought to work because it can delay the suicide attempt, allowing the individual to reconsider their actions, and giving others the opportunity to intervene.^{40,41} Strategies that actively encourage help-seeking or increase the likelihood of intervention by a third party might therefore enable means restriction to work.

Some might argue that introducing interventions to reduce suicides at suicide hotspots is not the best use of resources. Even if such critics can be convinced that preventing suicide at one site does not lead to more suicides at other nearby sites, they might still argue that reducing suicides at hotspots might not reduce the overall suicide rate. A study that compared US counties that had landmark bridges with counties that did not and showed that although the former had higher rates of suicide by jumping, overall suicide rates were similar in

each county.⁴² We argue that, although intervening at suicide hotspots might have only a small effect on the total suicide rate, it is important for other reasons: suicide attempts at these sites are often fatal and attract media attention, which can lead to so-called copycat acts; and those who work at or visit these sites for other reasons can inadvertently be affected.

Priority should be given to ongoing implementation and evaluation of initiatives at suicide hotspots not only because of their self-perpetuating nature as places where people can attempt suicide, but also because of the effect that suicides at these sites have for those who work at them, live near them, or frequent them for other reasons.

Contributors

JP designed and oversaw the meta-analysis, interpreted data, and wrote the report. LST searched the published work, screened articles, and extracted data with help from KK, MJS and JR. MJS did the analysis, with YTDC. All authors interpreted data and wrote the report, providing input into several drafts.

Declaration of interests

We declare no competing interests.

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