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Title

The effectiveness of structural interventions at suicide hotspots: A meta-analysis

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Summary

Background: Certain sites have gained notoriety as 'hotspots' for suicides by jumping. Structural interventions (e.g., barriers and safety nets) have been installed at some of these sites. Individual studies examining the effectiveness of these interventions have been underpowered.

Method: We conducted a meta-analysis, pooling data from nine studies.

Results: Following the interventions, there was an 86% reduction in jumping suicides per year at the sites in question (95% CI 79% to 91%). There was a 44% increase in jumping suicides per year at nearby sites (95% CI 15% to 81%), but the net gain was a 28% reduction in all jumping suicides per year in the study cities (95% CI 13% to 40%).

Conclusion: Structural interventions at 'hotspots' avert suicide at these sites. Some increases in suicide are evident at neighbouring sites, but there is an overall gain in terms of a reduction in all suicides by jumping.

Background

Around the world, certain man-made structures (e.g., bridges and viaducts) and natural points of elevation (e.g., cliffs) have gained notoriety as 'hotspots' for suicides by jumping.[1-10] Jumps from such sites have a relatively high case fatality rate,[11] cause significant distress – and sometimes physical harm – to bystanders,[12] and often receive prominent media coverage,[13] which may increase the risk of copycat acts.[14] Structural interventions (e.g., barriers and safety nets) have been put in place at some of these sites in an effort to reduce suicides by jumping.[12, 15] Some of these prevention efforts have sparked controversy, with opponents reportedly objecting to them on the grounds of aesthetics and cost,[16, 17] and because of suspicions that they just 'shift' jumping suicides to other sites.[18] A number of studies have investigated the effectiveness of these interventions, mostly through before-and-after designs (regarded as Level III evidence); stronger designs than this are difficult to mount for practical and ethical reasons. Although the existing evidence suggests that structural interventions show promise, the number of deaths available for analysis in each study has generally precluded the demonstration of interpretable reductions. We pooled data from the under-powered single studies of these interventions and subjected them to a formal meta-analysis. This approach gave us an authoritative means of assessing the effectiveness of this class of suicide prevention measures.

Method

Search strategy

We conducted a systematic search of bibliographic electronic databases MEDLINE, PsycINFO and Scopus in July 2012, with the following search string forming the basis of the search strategy: suicid* AND (bridge OR viaduct OR public* OR jump* OR leap* OR fall OR height OR drown* OR site*) AND (fenc* OR barrier* OR parapet OR net* OR restrict OR intervention OR prevent*). Terms were searched in the titles of records, and where applicable, mapped onto MeSH headings We also searched reference lists of key review papers.

Study inclusion criteria

To be eligible for inclusion in the meta-analysis, a study had focus on an intervention that involved the installation of barriers or equivalent structural measures designed to prevent suicide by jumping from a height. In addition, the study had to report data on suicides by jumping from the site both before and after the intervention.

Dataset construction

For each study, we extracted pre- and post-intervention counts of suicides at the site where the structural intervention was introduced and pre- and post-intervention exposure time (in years). We also extracted the equivalent information for other jumping sites in the same city from all studies where these data were reported. In two instances, we sought additional information from the study authors.

We constructed a dataset in which each row of data corresponded to a study observation period (pre- or post-intervention). The dataset included variables for the study identifier, the observation period, the count of the number of suicides at the site under study, and the exposure time over which the deaths were counted.

Statistical analysis

We used a random-effects Poisson regression analysis. Guevara et al[19] recommend an approach along these lines for circumstances in which the standard Mantel-Haenszel approach to meta-analysis is precluded by count data arising from varying exposure periods or count data with zero values; our study dataset had both features.

To estimate the impact of the interventions, we regressed the number of deaths on a variable distinguishing all pre-intervention periods from all post-intervention periods in the constituent studies; we included an offset term for exposure time. The effect size for on the pre-/post-intervention dummy variable was interpreted as a risk ratio – namely, the change in the expected number of suicides following the installation of the structural intervention. We included a random-effects parameter to account for inter-study variability, where the random-effects were assumed to be normally distributed.

We used the same modeling approach to estimate the effect of the interventions under study on suicides at nearby jumping sites (i.e., other than sites at which the interventions were introduced) and the net overall effect on suicides by jumping.

Heterogeneity was assessed using the median incident rate ratio (MIRR), a measure of heterogeneity for count data derived from the variance component of the normally distributed random intercepts. Values close to 1.0 indicate no heterogeneity.[20, 21]

Results

Figure 1 summarises the flow of our search strategy. We initially identified 194 records, 190 from our database searches and four from other sources. After excluding duplicates, we were left with 97. These records underwent an initial screening at the title and abstract level, and 75 were excluded on the grounds that they did not meet our eligibility criteria. We retrieved the full text articles for the remaining 22 records, and two of us (JP and GC) independently reviewed these. Eleven were excluded because they were narrative reviews, descriptive epidemiology studies or commentaries. Ultimately, 11 full-text articles representing nine independent intervention studies were available for inclusion in the meta-analysis. There were two instances where the same group of authors used the same core data in two papers, augmenting it with data from other sources or with follow-up data.[16, 17, 22, 23] There was one instance in which the same data were examined independently by separate investigators to determine the impact of the same intervention at the same site.[24, 25] These were regarded as separate studies, but their findings are discussed together.

[FIGURE 1 ABOUT HERE]

Table 1 summarises key characteristics of these nine studies. Six studies examined the effect of barriers installed on five separate bridges or viaducts – the Grafton Bridge (Auckland, New Zealand),[16, 17] the Clifton Suspension Bridge (Bristol, United Kingdom),[22, 23] the Ellington Bridge (Washington, DC, United States),[24, 25] the Memorial Bridge (Augusta, Maine, United States)[26] and the Bloor Street Viaduct (Toronto, Canada).[27] Two studies considered the effectiveness of fencing off road access to cliffs – Lawyers Head Cliff (Dunedin, New Zealand)[28] and Beachy Head (Sussex, United Kingdom).[29] The final study examined the effectiveness of installing a safety net below the top of Muenster Terrace (Bern, Switzerland).[30]

[TABLE 1 ABOUT HERE]

Table 2 presents observation periods and pre- and post-intervention counts of suicides by jumping, by study. Pre-intervention, there were 436 deaths over 77 study-years at the jumping sites, a mean of 5.7 deaths per year. Post-intervention, there were 21 deaths over 46.4 study-years, a mean of 0.5 deaths per year. Figure 2 (Panel A) shows that adjusting for study-to-study differences, the overall effect of the introduction of the interventions was an 86% reduction in the number of jumping suicides per year (RR = 0.14, 95% CI 0.09 to 0.21, p = 0.001).

[TABLE 2 ABOUT HERE]

At other jump sites in the same cities, there were 158 suicides over 57 study-years in the pre-intervention periods (mean, 2.8 deaths per year) and 150 deaths over 42 study-years in the post-intervention periods (mean, 3.6 deaths per year). Figure 2 (Panel B) shows that the interventions were associated with a 44% increase in the number of jumping suicides per year at nearby sites (RR = 1.44, 95% CI 1.15 to 1.81, p = 0.002).

Considering all jumping suicides – both those at the sites under study and those at nearby sites – there were 354 suicides during 57 pre-intervention study-years (mean, 6.2 deaths per year) and 171 deaths during 42 post-intervention study-years (mean, 4.1 deaths per year). The net overall effect of jump-site interventions on suicides by jumping was a reduction of 28% in the number of deaths per year (RR = 0.72, 95% CI 0.60 to 0.87, p = 0.001) (see Figure 3, Panel C).

[FIGURE 2 ABOUT HERE]

The heterogeneity test indicated study-to-study variation for all three meta-analyses (at sites, MIRR = 2.76; at other sites, MIRR = 3.50; at all sites, MIRR = 2.95).

Discussion

Interpretation of findings

Our meta-analysis provides strong evidence that restricting access to 'hotspot' sites reduces suicide deaths from jumps at those sites. We also show that, despite some substitution in terms of increases in jumping suicides from nearby sites, these structural measures save lives; there is an overall net reduction deaths.

The next question that many would ask is whether the reduction in jumping suicides achieved by restricting access to one suicide jump site has a tangible impact on the overall suicide rate in a given location, or whether there is substitution to other suicide methods. Although only two of the studies in our meta-analysis looked at general suicide trends following the installation of barriers on the bridge in question, both identified small decreases in the overall suicide rate in the given cities.[24-26]

In fact, the question of the impact of the specific intervention on the overall suicide rate may not be the right one to ask in the context of jumping suicides. In the countries in which the studies included in our meta-analysis took place, jumping from heights accounts for between 2% and 9% of male suicides and 3% and 15% of female suicides; other methods like hanging are far more common.[31] It is not reasonable to expect that reducing suicides by a method that only occurs with a moderate degree of frequency would shift the overall pattern of suicides, particularly because changes in suicides by other methods may be occurring for unrelated reasons.

The infrequency of jumping, relative to some other methods, has other implications for assessing interventions in this area. Some commentators have argued that suicide prevention strategies that rely on restricting access to means should predominantly be targeted at relatively high-frequency

methods.[32] We agree that this is desirable wherever possible, but would argue that other features of the method – like its lethality level and its impact on witnesses, both of which score highly in the case of jumping suicides – should also be taken into account in weighing benefits.

Of course, any thorough appraisal of a suicide prevention measure must also consider its costs. Structural interventions to prevent jumps can be expensive. However, these are generally fixed, one-off costs. Many other suicide prevention interventions may have lower start-up costs, but they carry recurrent costs, such as the ongoing employment of staff (e.g., clinicians), that make them more expensive in the long run. Consideration of these long-run costs is essential in any comparison of the cost-effectiveness of means restriction at 'hotspot' sites with alternative interventions.

Our findings concur, at least in part, with those from a recent study by Glasgow.[33] Glasgow took a different approach to the problem of under-powered studies, addressing the problem by assembling data from 3,116 US counties to estimate whether suicide rates in local areas with unsecured landmark bridges were higher than suicide rates in areas without such bridges, adjusting for various area-level factors. He found that 'exposure' to local landmark bridges was associated with an increased number of suicides by jumping (but that there was no positive association with overall rates of suicide in the adjacent local area). Glasgow's[33] approach essentially tested the negative proposition (does the absence of bridge barriers lead to an increased rate of suicides by jumping?), rather than the positive one (does the presence of bridge barriers lead to a decreased rate of suicides by jumping?). It did not distinguish between suicides by jumping from the landmark bridges and suicides by jumping from other sites in the local areas. For these reasons, our findings build on this work.

Our findings are consistent with the broader literature on means restriction as a suicide prevention measure. A recent systematic review by Mann et al[34] concluded that means restriction was one of

the few suicide prevention strategies for which there was sound evidence of effectiveness, citing examples like firearm control legislation, restrictions on pesticides, and detoxification of domestic gas. These strategies are thought to 'buy time', allowing the individual to reconsider his or her actions, and give others the opportunity to intervene.[32, 35] It has been suggested that restricting access to means may be particularly effective in circumstances where the individual is ambivalent about his or her wish to die (low intent) or is acting rashly (high impulsivity). Evidence from studies of survivors of jumping suicide attempts indicates that these individuals rarely go on to die by suicide,[12] suggesting that the low intent and high impulsivity criteria may be applicable here, at least in some cases.

Recommendations for policy and practice

We recommend that restricting access to suicide jump sites be given careful consideration in the suite of suicide prevention activities being undertaken in cities around the world. Some guidance exists as to the specifications necessary to ensure that barriers and other measures are effective,[15] and known 'hotspot' sites might be targeted. New structures could be designed to incorporate barriers in an aesthetically-pleasing way from the outset, or in such a way that modifications can be made later if they become problematic (e.g., footings constructed in readiness for barriers on new bridges). Efforts in this regard would require collaboration between suicide prevention experts, bodies responsible for infrastructure development, and local communities.

It goes without saying that restricting access to means at suicide jump sites should not be the only approach. The effectiveness of other interventions at these sites (e.g., telephone crisis lines) should also be explored. In addition, it would be desirable to investigate the choices that suicidal individuals make at sites with and without barriers. Learning from those who have made suicide attempts – or

been prevented from doing so – at particular sites might help to reduce the number of recurrent attempts.

Limitations of the meta-analysis

This meta-analysis had five main limitations, and these should be taken into account in interpreting the findings. Firstly, our search strategy may have missed some studies. Secondly, positive findings about the effects of restricting access to jumping sites may have been more likely to be published than negative findings. Thirdly, the restriction measures described in some studies may have been accompanied by other activities (e.g., telephone crisis lines), and the impact of these additional strategies is unmeasured.[36]

Fourthly, there was some evidence of heterogeneity across studies. This highlights the differences between the individual studies both in terms of the study designs (number of deaths and study duration), the underlying population sizes, and more substantially, differences in the jump sites themselves. The structural interventions included the used of barriers, blocking road access to jump sites or the installation of a safety net below the jump site. Nonetheless, the fact that the findings hold despite these differences points to the generalizability of the findings to other settings.

Finally, we acknowledge that the original studies were limited in terms of their capacity to examine substitution. Most examined jumping behaviour at nearby sites, which is clearly superior to ignoring the potential for substitution, but is still somewhat crude. Notwithstanding our earlier point about absolute reductions in the overall suicide rate not being the only arbiter of success, it should still be noted that the studies could not capture the extent to which individuals who were prevented from jumping by barriers and other structural measures may have travelled outside the area to jump, or may have adopted other methods.

Conclusions

Suicide attempts involving jumping from heights are often fatal, and they can have a severe and lasting effect on bystanders. For these reasons, intervening at jumping sites should be a priority. There is strong evidence that installing structures like barriers or safety nets at known jumping sites is an effective suicide prevention strategy. It averts suicide at these sites, reducing their occurrence to zero in many instances. Some increases in suicide are evident at neighbouring sites, but there is an overall gain in terms of a reduction in all suicides by jumping.

Key messages

- Sites which gain a reputation for suicides by jumping are a priority for preventive activities because of the fact that suicide attempts from these sites are often fatal, can have a devastating effect on witnesses, and may promote copycat acts.
- Various structural interventions – usually in the form of barriers – have been put in place at some of these sites, but these interventions have not always been well-received.
- Naysayers argue that such interventions are futile, because they simply shift the problem to other sites.
- Our study provided convincing evidence that these sorts of interventions not only reduce suicides by jumping at the sites in question, but also lead to an overall reduction in jumping deaths in the area.

Declaration of interests

The authors have no interests to declare.

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Figure 1: Study retrieval flow

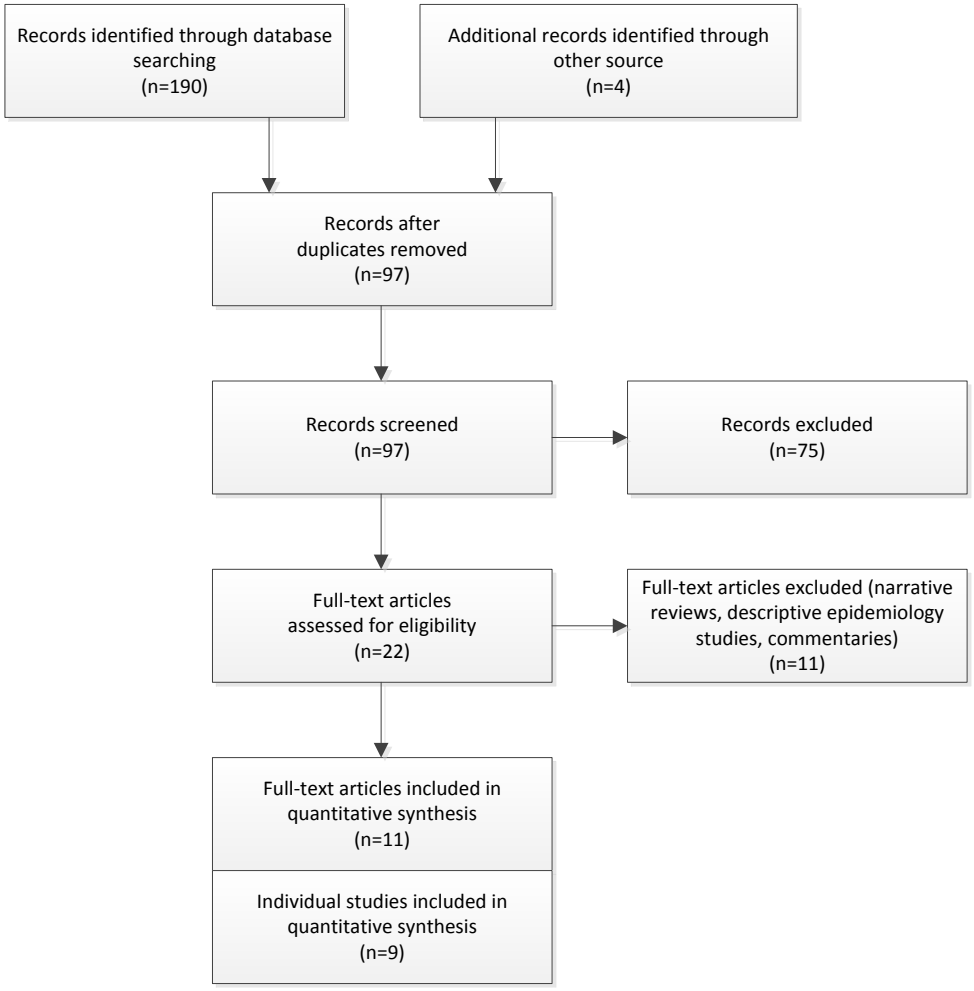


Table 1: Study characteristics

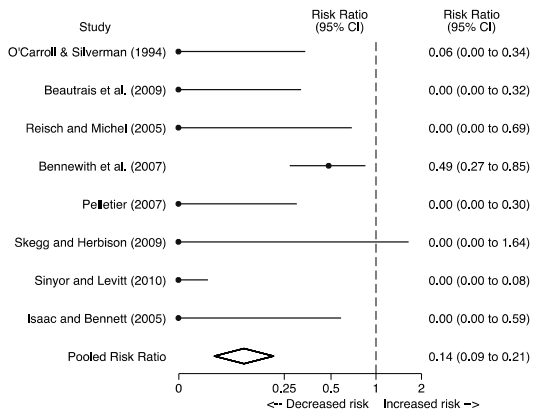
Author(s) and date	Setting	Intervention	Study design and observation periods
Beautrais (2001)[16]; Beautrais et al (2009)[17]	Grafton Bridge, Auckland, New Zealand.	Metal screens fixed above concrete parapets for purposes of suicide prevention, removed in 1996. Reinstallation of a barrier in 2003 with an improved curved glass design.	A-B-A (reversal) study assessing number and rates of suicides in three periods: • 1991-1995 (5-year period in which original barriers were in place); • 1997-2002 (5 year period in which no barriers were in place); and • 2003-2006 (5 year period in which new barriers were in place).
Bennewith, Nowers and Gunnell (2007)[22]; Bennewith, Nowers and Gunnell (2011)[23]	Clifton Suspension Bridge, Bristol, United Kingdom.	Two metre high wire fencing installed on main span in 1998.	Before-and-after analysis comparing number of suicides in two periods: • 1994-1998 (5-year pre-intervention period); and • 1999-2003 (5-year post-intervention period). Before-and-after analysis comparing number of suicides in two periods: • 1996-1998 (3-year pre-intervention period); and • 1999-2005 (7-year post-intervention period).
Issac and Bennett (2005)[29]	Beachy Head, Sussex, United Kingdom	Road access blocked in 2001 due to outbreak of foot and mouth disease.	A-B-A (reversal) study assessing the number and rates of suicides in three periods: • 1987-2000 (14-year pre-intervention period) • Jan 2001 to May 2001 (5 month period when access was blocked) • June 2001 to Dec 2001 (7 month period when access resumed)
Lester (1993)[24]; O'Carroll and Silverman (1994)[25]	Ellington Bridge, Washington DC, United States	Eight foot fence installed in 1986.	Before-and-after analysis comparing number of suicides in two periods: • 1979-1985 (7-year pre-intervention period); and • 1986-1990 (5-year post-intervention period).
Pelletier (2007)[26]	Memorial Bridge, Augusta, Maine, United States.	11 foot high fence installed on either side bridge in 1983.	Before-and-after analysis comparing number of suicides in two periods: • 1 Apr 1960 – 31 May 1983 (22-year pre-intervention period); and • 1 Jun 1983 – 31 Jul 2005 (22-year post-intervention period).
Reisch and Michel (2005)[30]	Muenster Terrace, Bern, Switzerland.	Four metre wide wire mesh net, seven metres below top of terrace installed in 1998 following high level of media attention.	Interrupted time series analysis assessing expected and observed numbers of suicides in two periods: • 1995-1998 (4-year pre-intervention period); and • 1999-2002 (4-year post-intervention period)
Sinyor and Levitt (2010)[27]	Bloor Street Viaduct, Toronto, Canada	Five metre high barrier constructed between April 2002 and June 2003 comprising closely-spaced steel rods supported by an angled steel frame.	Before-and-after analysis comparing number of suicides in pre- and post-intervention periods: • 1993-2001 (9-year pre-intervention period); and • 2003-2007 (5-year post-intervention period).
Skegg and Herbison (2009)[28]	Lawyers Head Cliff, Dunedin, New Zealand	Road access blocked in 2006 due to maintenance.	Before-and-after analysis comparing number of suicides in two periods: • 1 Aug 1996 – 31 Jul 2006 (10-year pre-intervention period); and • 1 Aug 2006 – 31 Jul 2008 (2-year post-intervention period).

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

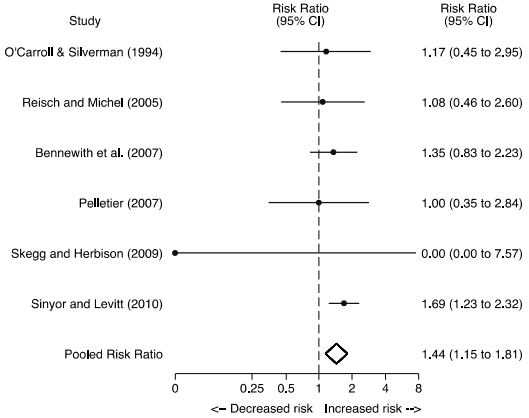
	Duration of observation period (years)		Jumping suicides at site				Jumping suicides at other sites				Jumping suicides at all sites			
			Pre-intervention period		Post-intervention period		Pre-intervention period		Post-intervention period		Pre-intervention period		Post-intervention period	
	Pre-intervention period	Post-intervention period	Total suicides	Suicides per year	Total suicides	Suicides per year	Total suicides	Suicides per year	Total suicides	Suicides per year	Total suicides	Suicides per year	Total suicides	Suicides per year
Beautrais (2001)[16]; Beautrais et al (2009)[17]	6.0	4.0	19	3.2	0	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bennewith, Nowers and Gunnell (2007)[22]; Bennewith, Nowers and Gunnell (2011)[23]	5.0	5.0	41	8.2	20	4.0	31	6.2	42	8.4	72	14.4	62	12.4
Issac and Bennett (2005)[29]	14.0	0.4	221	15.8	0	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lester (1993)[24]; O'Carroll and Silverman (1994)[25]	7.0	5.0	25	3.6	1	0.2	12	1.7	10	2.0	37	5.3	11	2.2
Pelletier (2007)[26]	22.0	22.0	14	0.6	0	0.0	9	0.4	9	0.4	23	1.0	9	0.4
Reisch and Michel (2005)[30]	3.0	3.0	7	2.3	0	0.0	12	4.0	13	4.3	19	6.3	13	4.3
Sinyor and Levitt (2010)[27]	10.0	5.0	96	9.6	0	0.0	90	9.0	76	15.2	186	18.6	76	15.2
Skegg and Herbison (2009)[28]	10.0	2.0	13	1.3	0	0.0	4	0.4	0	0.0	17	1.7	0	0.0
Total			**436**	**5.7**	**21**	**0.5**	**158**	**2.8**	**150**	**3.6**	**354**	**6.2**	**171**	**4.1**

Figure 2: Risk ratios for individual and pooled studies

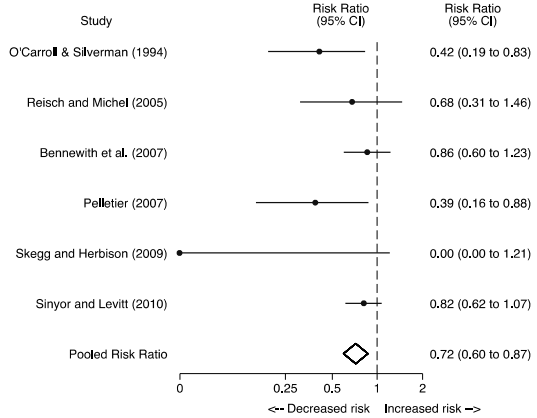
Panel A: Jumping suicides at site



Panel B: Jumping suicides at other sites



Panel C: Jumping suicides at all sites



Note: Individual study confidence intervals calculated using exact methods