

RESEARCH REPORT

Lethality of firearms relative to other suicide methods: a population based study

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Objectives: (1) To quantify lethality of firearms relative to other suicide methods, (2) to quantify the extent to which suicide mortality may be reduced by limiting access to firearms.

Methods: Data on suicides and hospitalised para-suicides that occurred in the state of Illinois from 1990 to 1997 were combined. Total number of episodes for each suicide method was estimated as the sum of the number of suicides and the number of para-suicides for that method. Gender and suicide method were used as proxies for intention to die, and estimated lethality of suicide methods within method-gender groups (for example, male firearm users). Logistic regression was used to quantify the lethality of firearms relative to other suicide methods. Excess mortality associated with the use of firearms was estimated by conservatively assuming that in the absence of firearms the next most lethal suicide method would be used.

Results: From January 1990 to December 1997, among individuals 10 years or older in the state of Illinois, there were 37 352 hospital admissions for para-suicide and 10 287 completed suicides. Firearms are the most lethal suicide method. Episodes involving firearms are 2.6 times (95% CI 2.1 to 3.1) more lethal than those involving suffocation—the second most lethal suicide method. Preventing access to firearms can reduce the proportion of fatal firearms related suicides by 32% among minors, and 6.5% among adults.

Conclusions: Limiting access to firearms is a potentially effective means of reducing suicide mortality.

Suicide prevention efforts date back at least to pre-Christian times, when Roman emperors made laws to curb the practice of tax evasion through suicide.¹ Modern efforts include suicide awareness and prevention programmes that aim to identify and treat suicidal individuals. Some of these targeted programmes have been effective in identifying those at risk for suicide.² For example, from 1991–97 during National Depression Screening Day, 316 700 people were screened for risk of suicide and provided referrals if needed.³ However, other efforts have not proved as effective.^{4–6} Many reasons exist for programmes' lack of success; one pervasive problem is the difficulties inherent in identifying and reaching people who are at risk for suicide.⁷ For example, although one third of suicide victims visit a physician shortly before they die, most do not divulge their suicidal intent or even their depressed mood.^{8–11} It seems that many, if not most, suicidal people are first noticed by mental health professionals only after a suicide attempt. For these people, surviving a suicide attempt presents their best chance of receiving appropriate care. Given the difficulties in identifying suicidal individuals, universal preventive efforts aimed at the entire community deserve serious consideration.^{12–13}

One such universal approach is to limit access to substances and products that are likely to be misused by suicidal individuals. The Arsenic Act of 1851 is an early example of this approach.¹⁴ More recent examples include reductions in the carbon monoxide content of domestic gas,^{15–16} development of less toxic antidepressants,¹⁷ and restrictions in the prescription of potentially lethal drugs.^{18–19} In some instances reduced availability of certain lethal substances was accompanied by contemporaneous reductions in the suicide rates,^{20–21} in other instances similar reductions in the availability of lethal substances were not accompanied by reduced suicide rates.²² Whereas it remains uncertain whether universal approaches to suicide prevention can actually prevent suicide on a large scale, it is likely that a consequence of limiting access to very

lethal and irreversible suicide methods is a population level reduction in suicide mortality (not attempts). The primary aim of this study is to quantify the reduction in suicide mortality that may result as a consequence of limiting access to firearms.

While previous studies have estimated the risk of suicide associated with the availability of firearms,^{23–31} there are no epidemiological studies that quantify the lethality of firearms relative to other suicide methods. This may be attributable in part to the difficulties inherent in collecting data on para-suicides (that is, suicide attempts), without which any estimate of lethality would be biased. (This bias, which emanates from sociological and psychological distinctions between para-suicides and suicides, will be considered below.) Here we greatly, but not completely, reduce this source of bias by combining data on hospital admissions for para-suicides with data on completed suicides. The specific aims of this study are: (1) to quantify lethality of firearms relative to other suicide methods, (2) to quantify the extent to which suicide mortality may be reduced by limiting access to firearms.

METHODS

Two sources of data, spanning the years 1990 to 1997, were used in the analysis presented below: data on completed suicides were compiled from annual mortality data files of the Chicago Department of Public Health; these files contain sterilised records abstracted from death certificates. Data on para-suicides were abstracted from administrative hospital discharge data compiled as part of an Illinois State mandate.³² These files contain information from acute care facilities that were operating in the state of Illinois between 1990 and 1997, but they do not include data from Veteran's Administration hospitals, nor from psychiatric hospitals. Suicides and para-suicides were identified by International Classification of Diseases external causes of injury codes:

Table 1 Distribution of suicide and hospitalised para-suicide episodes - Illinois 1990–1997

Suicide method (n)	Complete sample	Male	Female	Minor Below 18	Adult 18 and over
	% of total*	% of total*	% of total*	% of total*	% of total*
	% fatal†	% fatal†	% fatal†	% fatal†	% fatal†
Poisons‡ (35476)	74.5	58.8	87.8	84.7	73.0
	6.5	11.1	3.9	0.9	7.4
Firearms (5043)	10.6	20.2	2.3	3.9	11.5
	96.5	96.5	96.0	95.3	96.5
Suffocation§ (2574)	5.4	9.6	1.8	2.7	5.8
	90.4	90.7	89.0	65.2	92.0
Cuts¶ (2409)	5.1	6.1	4.1	4.8	5.1
	6.7	9.9	2.6	0.7	7.5
Crash/jump** (676)	1.4	2.2	0.8	0.5	1.6
	74.0	76.1	68.8	51.7	75.0
Exposure†† (183)	0.4	0.5	0.3	0.3	0.4
	56.3	64.0	43.5	6.7	60.7
Other‡‡ (1278)	2.7	2.5	2.9	3.1	2.6
	1.8	2.4	1.4	0.5	2.0
Total episodes	47639	21965	25674	5943	41696
Total fatal episodes	10287	8222	2065	394	9893

*Percentage of all episodes coded with the particular suicide method (for example, 74% of all episodes where with poisons). †Percentage of completed suicides from each suicide method (for example, 7% of episodes involving poisons were lethal). ‡Episodes involving prescription drugs, over the counter drugs and toxic substances such as gasoline and household cleaning substances. §Episodes involving hanging, strangulation, and suffocation. ¶Episodes involving cutting or piercing instruments. **Episodes involving crash into a moving object or jump from a high place. ††Episodes involving electrocution or exposure to heat or cold. ‡‡Episodes involving all other methods, includes episodes involving unknown methods and multiple methods (for example, firearms and poisons).

E950-E959,³³ and were classified into seven categories according to suicide method(s).

To reduce the possibility of double counting an episode, it was assumed that hospitalisation episodes that culminated in death also appeared as fatal episodes in the annual mortality files. Therefore, 183 hospital admissions that culminated in death were excluded from the analyses. These excluded episodes were similar to the 10 287 completed suicides that appeared in the annual mortality files. Compared with admissions that did not culminate in death, these fatal episodes were significantly more likely to involve males and older people (47 versus 31 years). Also, to reduce the bias associated with potential misdiagnosis of suicide as accident, we included in the study only episodes involving those ages 10 or older.³⁴

In the analyses below each para-suicide and each suicide was regarded as a unique episode. To avoid bias associated with examining either suicides or para-suicides to the exclusion of the other, data on completed suicides were combined with data on para-suicides. The total number of episodes for each suicide method was estimated as the sum of the number of suicide episodes (from the annual mortality data files) and the number of para-suicide episodes (from the hospital discharge files). For example, the total number of firearms related episodes (5043) include 96.5% suicides (table 1) and 3.5% para-suicides (not shown). The average risk of death for each method was estimated by dividing the number of fatal episodes by the total number of episodes for that method.

In determining the lethality of firearms relative to other suicide methods, a central analytical challenge involved controlling for the strength of individuals' intention to die. Suicidal individuals vary in the strength of their intention to die, which can influence their choice of a suicide method; this, in turn, can influence their probability of mortality. Therefore, to assess a suicide method's relative lethality, it is necessary to control for the effect of intention to die. In the absence of direct information, we used suicide method and gender as proxies for intention to die. Although choice of suicide method is a function of multiple factors,^{14 35 36} it is suggested that on average intention to die is more similar within methods than across methods. For example, on average, intention to die

among firearm users is more similar than between firearm users and those taking pills. Thus, grouping people by their suicide method can partially control for their intention to die. Moreover, because there are stable gender differences in intention to die,³⁷ grouping by gender should also partially control for the effect of intention to die. Thus, for the current analysis, we make the simplifying assumption that intention to die is relatively similar among groups of same gender individuals who used the same suicide method. For example, male firearm users constitute one such method gender group with relatively homogenous intention to die. Female firearm users constitute another method gender group with relatively homogenous intention to die.

Within each method gender group, however, the reported age related differences in suicide mortality³⁴ should remain. Specifically, we expect younger individuals within each method gender group to have lower suicide mortality than relatively older people. As detailed in the discussion section there are a number of reasons, such as younger individuals' relatively better health, to expect lower mortality among younger individuals. If no age disparity is found among members of a method gender group, where intention to die is relatively homogenous, then it is postulated that the suicide method is so lethal as to nullify the protective effect of younger age.

Finally, we estimated the excess mortality associated with the use of firearms by conservatively assuming that in the absence of firearms, the next most lethal method would be used. This involves the assumption that although suicide methods reflect individuals' intention to die, they do not reflect the likelihood of their attempting suicide.^{23 35} Suicidal individuals carry on their plans even in the absence of their preferred method, simply by using the next most lethal method. We will return to these assumptions in the discussion section.

RESULTS

From January 1990 to December 1997, among individuals 10 years or older in the state of Illinois, there were 37 352 hospital admissions for para-suicide and 10 287 completed suicides (table 1). Poisoning was by far the most common suicide

Table 2

Suicide method	(A) Method specific odds of death among adults compared with minors*, Illinois, 1990–1997													
	Overall		Exposure		Cut		Poisons		Suffocation		Crash		Firearms	
OR	3.0		21.8		9.0		6.8		6.1		2.7		1.3	
CI	(2.7 to 3.4)		(2.8 to 167.5)		(2.3 to 35.1)		(5.1 to 9.1)		(4.3 to 8.8)		(1.3 to 5.7)		(0.7 to 2.5)	

Age (n)	(B) Method specific percentage of episodes culminating in death by age group, Illinois, 1990–1997														
	M		F		M		F		M		F		M		F
<18 (457)	18.2	1.1	0.0	14.3	1.9	0.0	1.9	0.7	70.8	48.8	50.0	53.8	96.9	88.4	
18–25 (1557)	23.6	1.8	56.0	33.3	1.9	0.0	4.8	1.4	90.8	86.7	67.7	62.5	93.2	99.5	
26–34 (1427)	26.5	3.2	63.2	66.7	5.6	0.4	8.8	2.9	90.2	89.2	71.9	49.1	94.2	96.8	
35–44 (1661)	31.3	4.6	70.8	38.1	11.6	1.6	12.9	4.4	89.5	86.6	75.2	77.8	97.1	95.2	
45–59 (1711)	48.2	10.3	72.0	63.6	29.7	12.2	20.0	10.5	94.3	96.8	84.9	82.8	97.5	98.3	
60+ (2931)	76.1	21.6	92.3	45.6	35.7	28.9	41.2	18.8	96.5	96.5	96.2	90.9	98.5	97.4	

*Models include gender.

method among both men (59%) and women (88%). The other most prevalent methods among men were use of guns (20%) and suffocation (10%). Among women, the other most prevalent methods were cuts (4%), guns (2%), and suffocation (2%). Among minors, the most prevalent methods were use of poisons (85%), cuts (5%), and guns (4%). Overall, about 96% of episodes involving firearms and 90% of episodes involving suffocation were lethal. In contrast, 6.7% of episodes involving cuts, and 6.5% of episodes involving poisons were lethal (table 1).

From 1992 to 1997, hospital charges for suicide attempts totalled 169.4 million dollars or, on average, 28.2 million dollars annually. Poisoning episodes were the most prevalent and, as may be expected, they generated the most charges, amounting to 141.5 million dollars in the six year period. Each poisoning related episode generated on average \$5123 in charges. However, the most costly episodes were those involving firearms, generating an average of \$15 540 in charges per episode, for a total of 3.1 million dollars.

As would be expected women were more likely to attempt suicide, but men were more likely to perish (table 1). For all suicide methods, except firearms, suicide mortality is significantly higher among males than females independent of age (OR 4.5, 95% CI 4.2 to 4.8). Moreover, for all suicide methods, except firearms, suicide mortality is significantly higher among adults than among minors (OR 3.0, 95% CI 2.7 to 3.4) (table 2). The protective effect of youth is strongest for less lethal methods such as exposure (OR 21.8, 95% CI 2.8 to 167.5) and cuts (OR 9.0, 95% CI 2.3 to 35.1). This age disparity is diminished, but still significant, for more lethal methods such as suffocation (OR 6.1, 95% CI 4.3 to 8.8). Firearms are the only suicide method that is not significantly more lethal among adults than minors (OR–1.3, 95% CI –0.7 to 2.5). The protective effect of younger age is particularly pronounced when all suicide methods are considered simultaneously (table 2B). Suicide mortality, which is 7% among minors increases with every age increment to 64% among adults aged 60 or older. A similar trend is apparent among crash and exposure episodes. For episodes involving poisons and cuts, the age effect is pronounced only among those 45 and older. Suffocation is also more lethal among adults than minors, but among adults there is a flat trend. Firearms are the only suicide method that is equally lethal among all age groups.

Episodes involving firearms are 2.6 times (95% CI 2.1 to 3.1) more lethal than those involving suffocation and 8.0 times (95% CI 7.1 to 9.1) more lethal than those involving crash/jump (table 3). The increased risk of mortality associated with the use of firearms remains after controlling for gender and age. To estimate the excess suicide mortality attributable to the use of firearms, it was assumed that in the absence of firearms, all firearm users would use the next most

Table 3 Risk of death from firearms relative to other suicide methods*, Illinois, 1990–1997

	OR†	(95% CI)
Firearms (exposure)*	–	
Suffocation	2.6	(2.1 to 3.1)
Crash/jump	8.0	(6.4 to 10.2)
Exposure	18.0	(12.8 to 25.3)
Cuts	325.5	(256.8 to 412.7)
Poisons	270.4	(230.6 to 317.2)

*Firearm episodes are the exposure category. For example, firearm episodes are 2.6 times more lethal than suffocation episodes. †Model includes gender and age (continuous variable).

lethal method, which is suffocation. Thus, mortality attributable to the use of firearms was estimated as follows: the proportion of lethal suffocation episodes (a) (that is, 91% among men) was subtracted from (b) proportion of lethal firearm related episodes (that is, 97% among men), and the difference was divided by the proportion of lethal gun episodes (that is, (a–b)/b or (97–91)/97). Compared with the next most lethal method, the excess suicide mortality associated with firearms is 6% for men, 7% for women, and 32% for minors.

DISCUSSION

We found significant age and gender effects for all suicide methods except firearms. Overall, suicide mortality is significantly higher among adults than minors and among males than females. These age and gender disparities in suicide mortality become less pronounced with increasing lethality of the suicide method, strongly suggesting that these disparities reflect a high intention to die among users of the more lethal methods, particularly firearms. However, evidence also suggests that firearm users' exceptionally high suicide mortality cannot be entirely explained by their high intention to die.

We parcelled out the effect of intention to die by capitalising on the well documented stable differences in intention to die that are related to gender and the suicide method. We examined suicide mortality among groups of same gender individuals who used the same suicide method (for example, male firearm users) under the assumption that intention to die is fairly uniform among method gender groups. And we expected other trends in suicide mortality to remain. Specifically, we expected younger age to be protective of mortality. The most obvious reason for lower suicide mortality among younger individuals is that health is generally better among younger individuals. Moreover, minors are also less likely to have access to lethal doses of prescription drugs, are more

Key points

- Firearms are the most lethal suicide method independent of age and gender.
- Preventing access to firearms can reduce suicide mortality by 32% among minors who would have otherwise used firearms.
- Universal approaches to suicide prevention that do not require identification of at risk individuals deserve serious consideration.

likely to lack technical and cognitive skills to effectively use difficult methods such as hanging, and they are less likely to be alone for extended periods of time.

As expected, on average, younger individuals, have significantly lower suicide mortality than their older peers. For all methods, except firearms, younger age is associated with significantly lower suicide mortality independent of gender. Although the protective effect of younger age is less pronounced for more lethal methods, it remains significant even among those who used the second most lethal suicide method—suffocation. However, the considerable protective effect of youth vanishes among firearm users; for both males and females, suicide mortality is remarkably uniform across all age categories of firearm users.

For all methods except firearms, younger age protects against mortality regardless of suicide method and gender—our proxies for intention die. It seems that robust health and other characteristics of younger individuals lower suicide mortality independent of their intention to die. However, whatever protection younger age confers, firearms negate. It is unlikely that this lack of an age effect is entirely attributable to uniformly high intention to die among firearm users of all ages. Even among those who use suffocation, adults are six times more likely to perish than minors. The considerable contrast between firearms and all other suicide methods, as well as compelling clinical evidence,³⁶ suggest that some of the firearm related suicide mortality is attributable to factors other than intention to die, one of which is probably the extensive physical trauma of the bullet wound.

To estimate firearms' excess suicide mortality, we assumed that in the absence of firearms individuals would simply use the next most lethal method. Even under the conservative assumption that every firearm user would switch to a method involving suffocation, lack of access to firearms among minors, a population that is not legally allowed to purchase firearms, could reduce firearms related suicide mortality by as much as 32%. The associated reduction in hospital charges is \$4725 per firearm related episode.

The study's limitations must also be noted. Our method of controlling for victims' intention to die by proxy is imperfect. However, it is ethically and otherwise impossible to assess the intention to die of over 47 000 community dwelling individuals. Other limitations regard the possibility of incomplete counts and misclassification. Almost certainly a considerable number of suicide episodes resulted in neither death nor hospitalisation; these episodes were not included in this study. Moreover, this undercount is likely to have occurred differentially by suicide method. Episodes involving less lethal methods were less likely to result in death or hospitalisation and thus to be included in the study. Exclusion of these episodes would result in underestimation of firearms' relative lethality. Our list of completed suicides is also likely to be incomplete.^{37 38} Some suicides are likely to have been attributed to accidents or other causes, thus overestimating the relative lethality of firearms.

Information on admissions to psychiatric and VA hospitals was unavailable to us. Consequently, unsuccessful attempts from these sources are not included in the analysis, although

successful attempts are included, thus inflating the proportion of lethal episodes. This inflation may be considerable, given that a large number of suicides occur in psychiatric hospitals.^{39 40} However, there is no evidence that this inflation occurs differentially by suicide method, thus, it does not bias firearms' relative lethality. With regard to admissions to VA hospitals, we have no evidence suggesting a preference for certain suicide methods among this population. Consequently, the estimated relative lethality for each method should not be effected by the unavailability of data from VA hospitals.

In conclusion, because many suicidal people are unlikely to be identified before a suicide attempt, it is critical to reduce suicide mortality with universal prevention efforts that do not require individual level identification. Our findings suggest that firearm related suicides are associated with a disproportionate number of deaths, and limiting access to firearms can be a potentially effective community based approach to decreasing suicide mortality.

Fairly simple measures can be taken to limit access to firearms, particularly among minors. In the US firearms are readily available,⁴¹ and although Federal law prohibits purchase of firearms by minors, American youth have ready access to firearms.⁴² Nationally about 22 million children reside where at least one legally purchased firearm is stored⁴³; in about 10% of these households the firearm(s) are kept unlocked and loaded.^{43 44} Minors can also obtain firearms relatively easily through illegal markets⁴⁵ that are stocked primarily through thefts of firearms and by smuggling.⁴² Clearly, the most effective preventive measure is removal of firearms, particularly handguns, from the environment in which children live and play.⁴⁶ Other preventive measures include keeping firearms and ammunition separately and in locked storage, and use of trigger locks that prevent access by anyone other than the owner.⁴⁷ Legal interventions include holding firearm owners responsible for injuries caused by children who have accessed improperly stored firearms.⁴⁸ Moreover, citizen's adherence to these measures, coupled with state and local enforcement of regulations governing licensed dealers, can also reduce availability of firearms in illegal markets.⁴²

Unfortunately not all suicidal individuals would benefit from community based approaches such as these. The clinical literature attests to the single mindedness by which some pursue self annihilation repeatedly until they succeed.^{49 50} For these people, screening, surveillance, and other targeted programmes constitute parts of an important safety net.⁵¹ However, curbing access to firearms could benefit the many others. Given firearms' particularly high excess mortality among minors, this approach promises to be particularly effective in this population. Moreover, to the extent that changes in the social milieu are lasting, reductions in the availability of firearms can also lower the suicide mortality of future generations.^{52 53}

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