

Changing Times: A Longitudinal Analysis of International Firearm Suicide Data

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We investigated changes in the proportion of firearm suicides in Western countries since the 1980s and the relation of these changes to the change in the proportion of households owning firearms. Several countries had an obvious decline in firearm suicides: Norway, United Kingdom, Canada, Australia, and New Zealand. Multilevel modeling of longitudinal data confirmed the effect of the proportion of households owning firearms. Legislation and regulatory measures reducing the availability of firearms in private households can distinctly strengthen the prevention of firearm suicides. (*Am J Public Health*. 2006;96:1752–1755. doi:10.2105/AJPH.2005.075812)

Our analysis focused on international data on firearm suicides over different periods, which enabled a longitudinal perspective. To our knowledge, this is the first analysis to have such a focus. Proportions of firearm suicides in Western countries since the 1980s were compared with the proportions of households owning firearms within those countries, a well-known predictor of firearm suicide¹ and, moreover, homicide,² particularly femicide.^{3,4} Specifically, we analyzed whether changes in the proportions of households owning firearms were associated with changes in legislation and regulatory measures and whether changes in firearm legislation contributed to the prevention of firearm suicides.

METHODS

The data in this analysis were obtained from the following sources:

- Suicide data published in 1992 by Killias⁵ from the World Health Organization (WHO) database, which used *International Classification of Diseases, Eighth Revision*, and *International Classification of Diseases, Ninth Revision (ICD-8 and ICD-9)* codes,^{6,7} and data derived from the WHO database or, in some instances, data delivered on request from national statistical offices;
- Suicide data published in 1998 by Krug et al.⁸ (*ICD-8 and ICD-9* codes, mostly from the year 1993 and 1994);
- Data published by the WHO in the mortality database (<http://www.who.int/research/en/>); the data are limited to those countries using *International Classification of Diseases, 10th Revision (ICD-10)*,⁹ codes and include up to 3 years (1999–2001), if available; data compilation was performed by the authors;
- Data from the 1989, 1992, 1996, and 2000 International Crime Victims Surveys (<http://www.unicri.it/wwd/analysis/icvs/data.php>) on gun ownership (proportion of households owning firearms—legal or illegal)^{3,10,11};
- Gun ownership data, for the United States only, from the National Opinion Research Center General Social Survey data series, published in the *Sourcebook of Criminal Justice Statistics* (<http://www.albany.edu/sourcebook/pdf/t256.pdf> and [258.pdf](http://www.albany.edu/sourcebook/pdf/t258.pdf)); National Opinion Research Center data were used because they are collected annually.

Analysis of longitudinal data was done within the framework of random coefficient models (also called multilevel model for change, mixed models, or hierarchical linear models)¹²; the proportion of firearm suicides was modeled as a function of time, suicide rates, and the proportion of households owning firearms. The proportion of firearm suicides and the proportion of households owning firearms were introduced as logits to mitigate floor and ceiling effects. The following countries were included in the analysis: United States, Switzerland, Finland, France, Canada, Sweden, Australia, the Netherlands, England and Wales, Scotland, Norway, Spain, and New Zealand. The 1992 values for the

proportion of households owning firearms were not used in modeling except if necessary to replace missing 1989 values (applies to Sweden and New Zealand). This analysis was performed with the PROC MIXED procedure in SAS for Macintosh, Version 6.12 (SAS Institute Inc, Cary, NC).

RESULTS

The proportion of firearm suicides within overall suicides and the proportion of households owning firearms varied considerably across countries, and the proportions also varied over time (Table 1). On the one hand, firearm suicides have become more common in countries such as Switzerland, Germany, and the Netherlands, while on the other, firearm suicides are clearly declining, some dramatically, in England and Wales, Scotland, Canada, Australia, New Zealand, and Norway.

The statistical analysis of longitudinal data via random coefficient models (Table 2) confirmed that the main relevant effect on the proportion of firearm suicides derived from the proportion of households owning firearms. Model C, which was accepted as the final model, showed that the latter variable absorbed almost all variance from the 4 variance components. Additional effects (e.g., the interaction term of time and proportion of households owning firearms) did not contribute any noteworthy improvement to the model.

DISCUSSION

This longitudinal study with international data showed that the proportion of firearm suicides decreased simultaneously with the proportion of households owning firearms. This result is in line with the well-established association between availability of firearms at home and risk of firearm suicide.^{1,3–5,13–16}

Firearm suicides depend on the availability of the method more than other suicide methods. Firearm suicides result more often from impulsive decisions than other suicide methods and tend to be associated more often with alcohol abuse.¹⁷ Victims of firearm suicides were shown to have distinctly fewer previous suicide attempts (22%) in their psychiatric history than were victims of other suicide methods

TABLE 1—Proportion of Firearm Suicides From 3 Data Points, Compared With Crude Suicide Rates and Proportions of Households Owning Firearms, by Country: 1983–2000

Country ^a	Crude Suicide Rates (per 100 000 Population)			Proportion of Firearm Suicides, %			Proportion of Households Owning Firearms, %			
	~1983	~1993	~2000	~1983 ^b	~1993 ^b	~2000 ^b	1989	1992	1996	2000
United States	12.4 ^c	12.1 ^d	10.4 ^e	58.7	60.9	56.8	46.0	41.0	40.0	32.0
Switzerland	24.5 ^c	21.3 ^f	18.5 ^g	23.5	26.4	27.4	32.8	...	37.1	35.7
Finland	25.4 ^c	27.3 ^f	23.0 ^g	21.4	21.1	19.9	25.5	25.4	28.9	24.0
Norway	14.3 ^c	13.6 ^d	12.5 ^g	27.1	29.0	19.8	31.5	...	...	...
France	22.3 ^c	20.8 ^f	18.4 ^h	22.1	24.7	19.0	25.3	...	26.1	18.6
Canada	13.9 ^c	13.2 ^j	11.7 ^h	31.9	28.2	19.0	31.0	28.2	23.7	19.1
Austria	...	22.1 ^f	19.3 ⁱ	...	18.4	16.9	...	...	14.3	...
Sweden	18.2 ^k	15.8 ^d	13.3 ^g	11.6	13.3	12.2	...	16.8	16.9	16.9
Denmark	...	22.3 ^d	13.9 ^e	...	10.1	11.8	...	...	...	12.4
Australia	11.6 ^c	12.7 ^f	12.8 ^g	29.5	18.6	10.2	20.1	17.6	...	10.0
New Zealand	13.8 ^l	12.8 ^d	11.9 ^h	17.5	16.7	7.9	...	26.2	...	...
Germany	20.4 ^c	15.6 ^f	13.5 ^g	6.8	7.5	7.9	9.2 ^m	...	...	...
Portugal	...	14.8 ^f	11.7 ^j	...	8.6	7.6	...	...	...	13.8
Spain	6.5 ^c	7.8 ^d	8.1 ^g	7.0	5.5	5.5	12.7	...	...	...
The Netherlands	11.7 ^c	10.3 ^f	9.5 ^e	2.4	3.0	3.3	2.0	2.8	3.7	1.9
England and Wales	8.6 ^c	7.7 ⁱ	6.2 ⁿ	4.4	4.3	2.8	4.7	4.4	5.0	3.4
Scotland	10.5 ^c	12.2 ^f	12.4 ^o	6.6	2.7	1.8	5.1	...	4.7	3.3
Japan	...	16.7 ^f	24.5 ^e	...	0.2	0.2	...	...	...	0.6

Source. Killias⁵; Krug et al.⁸; World Health Organization mortality database (<http://www.who.int/research/en/>); International Crime Victims Surveys (<http://www.unicri.it/wvd/analysis/icvs/data.php>).

Note. Years were of variable length or were nominal year.

^aSorted by proportion of firearm suicides around 2000; Belgium and Italy were omitted because ICD-10 data was lacking.

^bThe same periods in columns 1 to 3 are valid for columns 4 to 6

^c1983–1986

^d1993

^e1999–2000

^f1994

^g1999–2001

^h2000

ⁱ1992

^j2002

^k1987–1990

^l1986–1989

^mFederal Republic of Germany (without the former German Democratic Republic).

ⁿ2001

^o2000–2001

(36%–70%).¹⁸ Furthermore, firearms are more lethal than most other suicide methods.¹⁹

In most countries with declining proportions of firearm suicides, the firearm legislation and the licensing of firearm ownership have become more restrictive. Measures introduced in Canada,²⁰ Australia,^{21,22} New Zealand (B.A Helland, PhD, P. Larrison, PhD, oral communication, May 2005), Norway (B.A Helland, PhD; P. Larrison, PhD; oral communication, May 2005), and the United Kingdom²³ include the following:

- Requiring mandatory registration for all weapons
- Extending the category “prohibited weapons”
- Requiring the licensee to substantiate the specific need for the weapon to obtain license approval
- Setting a minimum age for licensing (e.g., 18 years instead of 16)
- Requiring a 28-day waiting period before allowing the purchase of a firearm
- Periodic examination and renewal of licenses

- Interviewing new applicants and firearm owners and visiting them at home before licensing or renewing a license.

In most countries, supplementary settlements restrict the storage and transport of firearms, the purchase of ammunition, and rifle training.²⁴

Minor limitations of this analysis included the use of different data sources from different countries and data relying on changing code systems (ICD-8, ICD-9, and ICD-10). The multilevel model for change is suitable to include country-specific variation into modeling. Moreover, the current line of reasoning encounters 2 major difficulties: (1) suicide rates change over time for many reasons, and different patterns of coincidence emerge between trends in firearm suicide rates and trends in overall suicide rates²⁵; and (2) in Canada and Australia, firearm suicides declined, but other suicide methods, particularly hanging, increased.^{26–28} However, in most countries, overall suicide rates decreased as well.²⁹ Moreover, earlier research suggested that decreasing the availability of fatal means was followed by modest shifts, at best, to other suicide methods.^{24,30} Method substitution is indirect proof that suicide prevention focusing on specific methods may work, but one measure alone may not be as effective as combined restrictions.

Individual-level evidence showed that many people who are suicidal change their mind when their specific suicidal impulse meets with obstacles. Efforts to reduce or modify the availability of lethal means—detoxification of household gas, smaller sizing of drug packages, new listings for prescription-only drugs, and securing of bridges and other “hot spots”—have had a well-founded basis in suicide prevention. Reducing the availability of firearms is a logical and promising component in this strategy.

Suicide methods are a major target in suicide prevention.³⁰ The method-based strategy in suicide prevention is a step-by-step investment. Legislative measures restricting firearms or ammunition availability in private homes are one step forward. Many countries, particularly countries with high proportions of households owning firearms, such as the

TABLE 2—Results From Longitudinal Analysis on the Proportion of Firearm Suicides in 13 Countries

	Model A: Unconditional Means Model		Model B: Unconditional Growth Model		Model C: Composite Model	
	Estimate (SE)	P	Estimate (SE)	P	Estimate (SE)	P
Fixed effects						
Initial status (interception)	-1.82 (.30)	> .001	-1.63 (.30)	> .001	.431 (.316)	.19
Rate of change (time 0, 1, 2)			-.198 (.07)	.017	-.070 (.048)	.24
Suicide rate					-.033 (.015)	.052
Proportions of households owning firearms					1.03 (.087)	> .001
Variance components						
Within country	.118 (.033)	> .001	.026 (.010)	.011	.029 (.012)	.03
In initial status	1.15 (.465)	.014	1.14 (.457)	.012	.089 (.050)	.08
In rate of change			.053 (.026)	.04	.014 (.015)	.34
Covariance			-.010 (.077)	.89	.031 (.031)	.32
Goodness-of-fit						
Deviance	71.7		53.0		12.1	
Akaike's information criterion	-37.8		-30.5		-10.0	
Bayesian information criterion	-39.5		-33.8		-13.1	

United States or Switzerland, have yet to take this step ahead. ■

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Contributors

V. Ajdacic-Gross, U. Hepp, and W. Rössler were responsible for the design of the study. V. Ajdacic-Gross analyzed the data and drafted the brief. M. Killias, E. Gadola, M. Bopp, and C. Lauber contributed specific paragraphs. M. Killias reviewed data; M. Bopp supervised analysis; M. Killias and E. Gadola reviewed legislation; U. Hepp and C. Lauber performed medical review; and U. Schnyder, F. Gutzwiller, and W. Rössler completed political review.

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Human Participant Protection

No protocol approval was needed for this study.

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