



Austrian firearm legislation and its effects on suicide and homicide mortality: A natural quasi-experiment amidst the global economic crisis

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ABSTRACT

Background: Restriction of access to suicide methods has been shown to effectively reduce suicide mortality rates.

Aims: To examine how the global economic crisis of 2008 and the firearm legislation reform of 1997 affected suicide and homicide mortality rate within Austria.

Methods: Official data for the years 1985–2016 for firearm certificates, suicide, homicide, unemployment rates and alcohol consumption were examined using auto regressive error and Poisson regression models.

Results: Firearm certificates, total suicide mortality rate, suicide and homicides by firearms, and the fraction of firearm suicides/homicides among all suicides/homicides decreased after the firearm legislation reform in 1997. However, significant trend changes can be observed after 2008. The availability of firearm certificates significantly increased and was accompanied by significant changes in trends of firearm suicide and homicide rates. Concurrently, the total suicide mortality rate in 2008, for the first time since 1985, stopped its decreasing trend. While the total homicide rate further decreased, the fraction of firearm homicides among all homicides significantly increased.

Conclusion: The initially preventative effect of the firearm legislation reform in Austria in 1997 seems to have been counteracted by the global economic downturn of 2008. Increased firearm availability was associated with corresponding increases in both firearm suicide and firearm homicide mortality. Restrictive firearm legislation should be an imperative part of a country's suicide prevention programme. Although firearm legislation reform may have long-lasting effects, societal changes may facilitate compensatory firearm acquisitions and thus counteract preventive efforts, calling in turn again for adapted counter-measures.

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1. Introduction

The firearm availability hypothesis suggests that reduction of firearm availability may prevent suicides. The evidence for its cogency is documented by three major study types: First, cross-sectional ecological studies show both an association between regional firearm availability and firearm deaths, as well as an

association between the strictness of regional firearm legislation and corresponding regional firearm mortality [1–3]. Second, longitudinal studies show that changes in firearm availability over time are associated with corresponding changes in firearm deaths [4]. Third, quasi-experimental longitudinal studies examining the effects of firearm legislation strengthening or other interventions aiming at the reduction of availability show corresponding declines of firearm related deaths after the intervention [5–9].

The aim of this study was to follow-up our previous study on the effects of the 1997 firearm legislation in Austria, which examined the time period between 1985 and 2005 [9]. Following

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that period, global societal changes were observable: The financial [10] and the refugee [11] crises both increased perceived threats in parts of the population [12], yielding media reports on increases in firearm possession [13]. Given that the developments after 2008 had a societal impact, we hypothesized a significant increase in (a) firearm availability and simultaneous and significant increases in (b) firearm suicide and homicide rates in Austria.

2. Materials and methods

We expanded our previous longitudinal approach [9] and examined suicide and homicide rates in Austria recorded between the years 1985 and 2016.

Firearm legislation in Austria

A Firearm certificate needs to be applied for at the local authorities and grants permission to the applicant of owning a registered and non-concealed firearm. The 1997 legislation reform added a number of prerequisites necessary before obtaining a firearm certificate: 1) Background checks (no convictions for serious offences or multiple minor offences registered); 2) passing a psychological test; 3) installation of safe storage for firearm and ammunition; 4) completing a course on safe firearm handling as well as storage; 5) being at least 20 years old; 6) applicants need to provide proof of danger to their life and need to argue that the use of firearms would be an adequate response. Only after a firearm certificate is granted by the local authorities, a firearm can be purchased and registered. Several weapons are banned from the citizenry (e.g. military style rifles, hand-grenades, pump-guns, any concealed weapon and brass knuckles).

2.1. Data collection

For the period of interest, 1985–2016, data on firearm certificates were obtained from the Ministry of the Interior. For the same time period data on population size, unemployment rates, alcohol consumption in litres of pure alcohol per capita, as well as the number of suicides, firearm suicides and firearm homicides (coded according to ICD-9 or ICD-10 respectively), were obtained from Statistics Austria. Data on total homicides encompass all convictions for both, murder and man-slaughter and were retrieved from Statistics Austria. For comparative reasons, we followed the same data acquisition methodology used in a previous report [9].

2.2. Statistical analysis

To assess the effect of the firearm legislation reform enacted in 1997 and possible effects of the economic recession after 2008, regression of the number of firearm certificates per 100,000 inhabitants on the year was performed with an autoregressive

error model of first order to compare time trends before and after the legislation reform and following the 2008 economic recession.

Similarly, Poisson regression models were performed to compare the time trend in firearm suicides, the fraction of firearm suicides among all suicides, the total homicides (the sum of all convictions due to homicide and man slaughter) the number of firearm homicides, as well as the fraction of firearm homicides among all homicides, before and after the legislation was enacted and before and after 2008. The SAS procedure *Genmod* was used for this purpose. To allow for underdispersion in both models for firearm suicides, we allowed the variance estimate to depend on an underdispersion factor estimated from the data.

The regression model included linear time trends allowing for change points in 1998 and 2008. Changing population sizes were taken into account by including respective offsets into the model. To distinguish between the effects of the new legislation and other factors which are known to influence suicide and homicide rate, the unemployment rate and the average consumption of alcohol per capita were included into the analyses. The ratio of young men (<20 years of age) in the population was included as a covariate in the regression model for homicides. The included parameters were chosen to ensure comparability with a previous study and due to a limited availability of variables from the national statistical bureau.

To facilitate a more detailed data analysis we have not examined differences in mean mortality rates of time periods but have examined their respective slopes for significant alterations in direction.

All parameter estimates are reported with 95% confidence intervals. The analysis is based on firearm certificate numbers, suicide counts, firearm suicide counts, firearm homicide counts, and population numbers from 1985 to 2016. The two-sided significance level was set to ≤ 0.05 . Data analysis was conducted in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Firearm certificates

In the years prior to the firearm legislation reform the number of new firearm certificates granted per 100,000 continuously increased, from 2632 in 1985 to 4526 in 1998. Following the legislation reform, the number of new certificates per 100,000 decreased to 2972 in 2008 and further decreased to 2692 in 2016. Significant positive autocorrelation was observed ($p < 0.0001$).

For the number of firearm certificates per 100,000 a model with lag 1 autocorrelation and no confounders identified a significant increase of 141 additional certificates per year for the period of 1985–1998 (95% CI [108,174], $p < 0.0001$) and a significant decrease of -132 per year for 1998–2008 (95% CI [-171,-92], $p < 0.0001$). For the period of 2008–2016 a significant decrease of

Table 1

Parameter Estimates derived from the Poisson regression model with 95% confidence intervals without confounders. (A growth factor of, e.g. 1.05 indicates an increase of the suicide rate by 5% per year).

Variable	Growth Factor Before 1998	Growth Factor After 1998	Percentage change of the growth factor	Growth Factor After 2008	Percentage change of the growth factor
Total number of Suicides	0.976 (0.973, 0.981)	0.974 (0.969, 0.978)	- 0.3% (- 1.0%, 0.5%)	0.990 (0.984, 0.997)	1.7% (0.8%, 2.7%)
Total number of Firearm Suicides	1.000 (0.994,1.006)	0.953 (0.947, 0.960)	- 4.7% (- 5.7%, - 3.6%)	1.006 (0.996, 1.015)	5.4% (3.9%, 7.0%)
Percentage of Firearm suicides among all suicides	1.024 (1.018, 1.030)	0.979 (0.972, 0.986)	- 4.4% (- 5.4%, - 3.3%)	1.016 (1.006, 1.026)	3.8% (2.2%, 5.3%)
Firearm Homicides	0.998 (0.973, 1.023)	0.904 (0.874, 0.934)	- 9.4% (- 14.0%, - 4.6%)	1.023 (0.972, 1.076)	13.2% (4.9%, 22.2%)
Percentage Firearm homicides among all homicides	1.060 (1.032, 1.087)	0.936 (0.905, 0.968)	- 11.6% (- 16.2%, - 6.9%)	1.010 (1.045, 1.157)	17.5% (8.8%, 28.3%)

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