



Gun control and suicide: The impact of state firearm regulations in the United States, 1995–2004

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ABSTRACT

Objective: To empirically assess the impact of firearm regulation on male suicides.

Method: A negative binomial regression model was applied by using a panel of state level data for the years 1995–2004. The model was used to identify the association between several firearm regulations and male suicide rates.

Results: Our empirical analysis suggest that firearms regulations which function to reduce overall gun availability have a significant deterrent effect on male suicide, while regulations that seek to prohibit high risk individuals from owning firearms have a lesser effect.

Conclusions: Restricting access to lethal means has been identified as an effective approach to suicide prevention, and firearms regulations are one way to reduce gun availability. The analysis suggests that gun control measures such as permit and licensing requirements have a negative effect on suicide rates among males. Since there is considerable heterogeneity among states with regard to gun control, these results suggest that there are opportunities for many states to reduce suicide by expanding their firearms regulations.

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1. Introduction

1.1. Firearms and suicide

Suicide is a major cause of preventable death. In 2006, more than 32,000 suicides occurred in the United States, as compared with approximately 18,000 homicides. In the United States, suicide was the 8th leading cause of death for males, and the 19th leading cause of death for females in 2006. For every suicide, there were more than ten hospitalizations for non-fatal attempts. In 2006, on average 46 Americans committed suicide with a firearm every day, accounting for approximately 50 percent of all suicides [1].

Prevention of suicide is an important part of the American public health agenda, and the goal of many programmatic activities undertaken by the Centers for Disease Control and Prevention (CDC) and other national and state agencies. In an attempt to combat this problem, spending by state mental health agencies (SMHAs) in the U.S. totalled \$ 30.7 billion dollars in 2006 [2]. In recent years, restricting access to firearms and other lethal means has been increasingly recognized as one of the most effective strategies for suicide prevention (for an excellent review of this literature see, for example [3]), and is one of the key elements of suicide prevention in countries such as England [4], and Denmark [5].

There is a considerable body of empirical work that has documented a positive relationship between access to firearms and suicide (e.g. [6,7]). In fact, much of the decline in suicide in the United States over the past decades has been linked to the reduced prevalence of firearms (see for example [7–9]). Although the respective roles of

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self-selection and availability in explaining the relationship between guns and suicide have not been completely resolved, the implication in either case is that reducing access to firearms should reduce suicide [10]. Restricting access to firearms has been recommended as a suicide prevention strategy by national and international organizations such as the CDC and the WHO. Gun control policies can serve to reduce overall gun availability by creating barriers to firearm ownership. Additionally, firearms policies can also prevent individuals who are at a relatively higher risk of suicide from purchasing firearms.

1.2. Gun control

Gun control is a highly contentious issue in the American political debate. Guns are common in the United States—40 percent of Americans reported having a gun in their home in 2009 (see [11]). Calls for increased regulation are based on the belief that restrictions will reduce gun violence. Regulation is opposed by those who claim infringement on the constitutional right to bear arms, and/or argue that firearm ownership deters crime. In the academic literature, the efficacy of gun control in reducing violence has received considerable attention, although little consensus has emerged from the empirical work (e.g. [9,12–14]).

The current era of gun control in the United States originated with the Brady Handgun Violence Prevention Act (1993)², more commonly known as the Brady Bill. The Brady Bill established a federal requirement for a waiting period of up to five days before the transfer of a handgun to a purchaser. During this period, a background check is performed, which is intended to prohibit individuals with criminal backgrounds from purchasing firearms. The transfer of the handgun is completed whether or not the background check is finalized within the five-day period. The federal waiting period was phased out in 1998 with the development of the National Instant Criminal Background Check System (NICS), administered by the Federal Bureau of Investigation (FBI). Over time, many states have passed laws which matched or surpassed the federal minimums.

There are many different types of state firearm regulations. Some seek to establish general oversight over individuals owning firearms, and mainly consist of permit, registration, and/or license requirements, and bans on the purchase of firearms by minors. These laws also facilitate the tracing of firearms used in crimes to original purchasers. Other state laws seek to prevent gun trafficking and the use of firearms in crimes. These consist of bans on the sale of certain types of firearms, and restrictions on the number of firearms that can be sold to individuals. Restrictions on carrying concealed weapons serve a similar purpose. A number of laws are designed to prevent firearm ownership by individuals considered disproportionately likely to commit gun crimes. These laws include prohibitions on gun ownership by those with criminal histories, such as conviction for a felony, misdemeanor, or domestic violence offence, as well as those with a history

of mental illness, and alcohol or drug problem, and minors. The requirement of a “cooling off” period of some specified period before the purchase can be completed is a measure designed to reduce the consequences of impulsive firearm purchases.

There is considerable variation in the comprehensiveness of firearm regulation across U.S. states. Some states have almost no firearm regulation of their own. Forty-four states have a provision in their state constitutions similar to the Second Amendment of the Bill of Rights (the exceptions are California, Iowa, Maryland, Minnesota, New Jersey, and New York). Firearm license holders are subject to the firearm laws of the state in which they are carrying and not the laws of the state in which the permit was issued. Reciprocity between states may exist for certain licenses such as concealed carry permits. These are recognized on a state-by-state basis.

Some firearms regulations are more relevant to suicide prevention than others. Restrictions banning the purchase of guns by convicted felons, or laws banning the sale of “Saturday Night Specials”, for example, have little obvious applicability to suicide. Yet other categories of restriction are potentially more salient, particularly those that reduce overall firearm availability. Permit requirements create barriers to gun ownership and may also serve to prevent impulsive purchases. The prohibition of purchases by minors serves a similar function. Some of the “prohibited persons” categories, such as those related to mental illness, a drug or alcohol problem, or history of domestic violence problems may theoretically be relevant to suicide prevention.³ Mental illness is the single most important risk factor for suicide, and substance abuse and domestic violence are also risk factors. However, while the criteria for “prohibited persons” categories vary by state, they are generally based on fairly serious incidents, such as hospitalization against one’s will or conviction records. Such bans are likely to identify only a fraction of the population with mental health, substance abuse, or domestic violence problems.

At the state level, the comprehensiveness of gun control laws tends to be correlated with firearm prevalence. The causality most likely runs in both directions, since restrictive gun control regimes reduce gun ownership, yet these laws are more likely to be passed in states where overall gun ownership rates are low and the population of gun rights advocates is relatively small. In general, Western and more rural states have fewer gun control restrictions and higher rates of gun ownership as compared with more urbanized states in the Northeast. These states also have significantly higher rates of suicide, particularly firearm suicide.

It should be noted that gun control is only one of the factors that affect gun ownership. Aside from geographical patterns related to urbanization, popularity of hunting, and so forth, there are also trends in gun ownership at the

² The Gun Control Act (1968) was the first firearm act in the USA.

³ In some states, the alcohol regulation means that sale of firearms are prohibited to people who are intoxicated at the time they are trying to buy them, while in other states it refers to people with a documented alcohol problem. Indeed, in some states it covers both situations.

national level. Widespread anxiety can lead to an increase in firearm purchases, as was the case shortly after September 11th, 2001. Similarly, economic trends can potentially affect the propensity toward gun ownership—although the direction of the effect is not certain. Concern about crime associated with rising unemployment may result in increased gun ownership, while unemployment itself may make guns less affordable to more people. The recent recession does not seem to be associated an increase in gun purchases, as the proportion of households reporting a gun between October 2007 and 2008 was unchanged (see [11]).

2. Gun control and suicide: empirical evidence

Much of the empirical evidence on gun control comes from the United States [15] and might not be applicable to other countries [16]. One excellent review of gun control in the United States, framed within the context of historical and rational choice theory, covers attempts to curb firearm violence in that country and the success of such measures, yet has relatively little treatment of the relationship between gun control and suicide [17].

In an important early study of gun ownership and suicide, Kellerman et al. [18] found that individuals who commit suicide in their own homes were disproportionately likely to own a gun. In general, the literature on gun control and suicide has found a negative relationship between firearm restrictions and suicide. However, most of these studies lack a strong design and are essentially pre- and post-comparisons [16]. Lambert and Silva [19] perform a literature review of studies in the United States and Canada and conclude that available information generally supports the notion that gun control reduces suicide rates, particularly among males. A recently published analysis suggests that states where background checks are conducted locally have lower rates of firearm suicide and homicide [20].

Several other studies find no empirical evidence in favor of a relationship between firearms regulations and suicide. However, one study has a weak design, while the other does not capture the most relevant types of firearms regulations. Price et al. [21] use cross-sectional state data for 1999 to perform a simple partial correlation analysis between several types of gun control laws and suicide rates. Their results suggest that gun control laws were not significantly related to suicide in 1999, even after controlling for firearm prevalence. Rosengart et al. [22] conduct a study of the relation between firearm regulations and homicides and suicides using state panel data over 1979–1998. They fail to uncover a statistically robust link between suicide rates and firearm regulations. However, most of the regulations they examined—such as bans on carrying concealed weapons, “junk gun” bans, and quantity sales restrictions are not particularly relevant to suicide.

Several studies in other countries where regulatory change restricted general access to firearms have found evidence of an effect on suicide. Cheung and Dewa [23] examine the relationship between suicide and the implementation of new restrictions on firearms (Bill C-17), using time series data from Canada. They concluded that there was a relationship between means used by young peo-

ple and the imposition of the restrictions. In the case of New Zealand, Beauvais et al. [24] find that after the introduction of legislation restricting ownership and access to firearms, firearm suicides significantly decreased, particularly among the young. Ozanne-Smith et al. [25] similarly conclude that the implementation of a strong reform in New Zealand lowered firearms deaths, particularly suicides. An evaluation of the 1996 National Firearms Agreement (NFA) in Australia documents a decline in firearm suicides after the implementation of the agreement [26]. However, these findings may be confounded with an overall decline in gun ownership that preceded the NFA. Additionally, there was some evidence of increased suicides by hanging.

In Europe, there are a few studies examining the efficacy of firearm regulation in reducing firearm suicides and homicides. For example, in Austria, Kapusta et al. [27] provide evidence that the introduction of restrictive firearm legislation reduced both firearm suicide and homicide. Also, a number of studies in the UK [28,29] have shown that changes in firearm legislation have led to fewer firearm suicides. Another analysis of Austria found that firearm regulations enacted in 1997 had a statistically significant effect on suicide rates [30]. A very recent study in Switzerland, finds a positive association between firearm ownership and firearm suicides at the local level [31].

Much of the empirical literature is based on simple correlations or time series analysis. Most of these models cannot account for correlations that arise between suicide deaths and firearm availability due to exogenous factors. Furthermore, there are many factors affecting suicidal behavior and gun ownership which are not observable. A panel data approach is more compelling in this context, as it is possible to control for unobserved heterogeneity across states. Similarly, time varying factors that affect all states in the same way can be controlled by using fixed specific effects. Additionally, there are many socioeconomic factors that might influence suicide deaths, and can be included in a panel data model.

3. Empirical model and data

3.1. Empirical model

The basic model that motivates the empirical analysis is that firearm availability affects suicide rates, and that gun control affects firearm availability (see for a discussion of the mechanisms by which firearms might affect death rates [9]). Our hypothesis is that regulations such as permit requirements, which create overall barriers to gun ownership, are the most important way type of gun control from the standpoint of suicide prevention. While it is possible that “prohibited persons” categories can affect the likelihood that certain persons at above average risk of suicide will obtain firearms, the ways in which these categories are defined in most cases will result in the prohibition of a relatively small proportion of people at risk. Firearms regulations designed to prevent gun trafficking or other criminal activity involving guns are not expected to influence suicide rates.

There are several potential complications to this simple model. The first is that of state variation in attitudes towards guns is likely to affect both firearm prevalence and the comprehensiveness of gun control regulation. Additionally, views toward gun ownership evolve over time. Finally, there is the problem of the measurement error of gun ownership.

The basic model can be expressed with two equations:

$$S = \alpha + \beta G + \mu \quad (1)$$

$$G = \delta - \Delta R + \Phi \quad (2)$$

where S is suicide, G is firearm prevalence, and R is firearms regulation. The reduced form is:

$$S = \alpha + \beta\delta - \beta\Delta R + \beta\Phi + \mu \quad (3)$$

The potential endogeneity of firearm prevalence with respect to gun control is reflected in the identifying equation,

$$R = \omega + \eta G + \varphi \quad (4)$$

However, G is not measured annually. For our main specification we estimate the reduced form Eq. (3), thereby assuming that η is zero. In an alternative specification, we proxy for G by using the number of hunting licenses per capita, a statistic which is collected annually for all states.

The dependent variable, S_{it} , is the number of suicides for age group $i=15-24$, $25-44$, $45-64$, and $65+$; in state $j=1, \dots, 50$ during the year $t=1995, \dots, 2004$. The independent variables included in the model were based on previous studies of suicide. In particular, the variables selected were: education, income, alcohol consumption, the proportion of the population over age 65, and the proportion of non-Hispanic white population. Each model also includes the relevant population size as a right hand side control variable to normalize by exposure. The specification includes state fixed effects that account for potential unobserved heterogeneity across states. The fixed effects model is appropriate in this case given the almost complete population coverage by the sample and it is likely that the omitted variables captured by the α_i are correlated with some of the included covariates [32]. We also account for the time effect over the years by including time dummies.

The expected value of the number of suicides, conditional on the independent variables is assumed to follow a negative binomial distribution with expected value

$$E \left[\frac{S_{it}}{X_{it}} \right] = \mu_{it} = \exp(x'_{it}\beta) \quad (5)$$

and variance function

$$\text{Var}[\mu_{it}] = \mu_{it} + \alpha(\mu_{it}^2) \quad (6)$$

The negative binomial distribution was assumed since the dependent variable is a count and over-dispersed relative to the Poisson distribution which assumes that the mean is equal to the variance. The negative binomial distribution accounts for extra Poisson dispersion through the quadratic term in the variance function [33].

We face several identification challenges. The first is that gun control regulations by state tend to change slowly,

so there tends to be relatively little within-state year-on-year change. Further, once states adopt particular gun control regulations, they never remove them. For these reasons, it is not possible to analyze leads and lags, which would be a desirable robustness check. To maximize variation, we have created several indices of categories of gun control regulations, which are additive measures of individual measures. The total sample contains 500 state-year observations. The sample period (1995–2004) was chosen because data on gun control regulations by state are not available before 1995, in part because there are relatively few state regulations. Since nearly ninety percent of firearm suicides are committed by males [1], we have excluded females from the analysis. The analysis was conducted using STATA v.10 statistical software.

3.2. Data

3.2.1. Dependent variable

Data on the number of suicides in states over the period 1995–2004 come from the Centers for Disease Control and Prevention (CDC). Deaths included in the study are those categorized as suicides according to the International Classification of Diseases (ICD). In 1999, there was a change in the classification system from ICD-9 to ICD-10. This change in ICD version did not influence suicide classification. For 1995–98, suicide deaths were coded as E950–E959. Starting in 1999 and later, suicide deaths were coded as X60–X84, Y87.0, and U03.

Table 1 displays the average age adjusted male suicide rates⁴ across US states for the years 1995–2004.⁵ As **Table 1** shows reported suicide rates in the US vary considerably across states. The annual average male suicide rate for the whole country during the study period was 21.05 per 100,000. As can be seen, suicide rates vary considerably across states. The suicide rate in Nevada (34.2), for example, is nearly thrice that in New York (11.3). Also it can be seen from the standard deviations that the suicide rate varied substantially over time in each state.

3.2.2. Independent variables

3.2.2.1. Socio-economic variables. Data on state personal income (*income*) were obtained from the Bureau of Economic Analysis and deflated by the consumer price index (CPI) extracted from the Bureau of Labor Statistics (BLS). Unemployment rates (*unemployment*) also come from the BLS. Data on per capita ethanol consumption of beer (*beer*), an estimate for the amount of pure ethanol consumption per capita, was extracted from the NIIA Surveillance Reports. Alcohol consumption and economic conditions have been linked to suicide in a number of population level studies (e.g. [34,35]). The percentage of people over 65 (*psh65*) years of age and the proportion of the population which is non-

⁴ For making comparisons across states and over time, the usual practice is to use age adjusted suicide rates that standardize the rates across the age distribution of the population of interest.

⁵ We do not show average suicide rates over 1995–2004 because of the relative position of the states is basically unchanged during the study period.

Table 1

Average age-adjusted male suicide rates (per 100,000 pop), by state, 1995–2004.

State	Average	Std. Dev.
Alabama	21.13	1.46
Alaska	31.45	4.05
Arizona	26.37	1.52
Arkansas	22.95	0.97
California	16.79	1.85
Colorado	26.30	2.37
Connecticut	13.59	1.40
Delaware	18.75	2.29
Florida	21.64	1.28
Georgia	19.64	0.99
Hawaii	16.28	1.70
Idaho	27.26	2.32
Illinois	14.50	0.99
Indiana	20.31	1.17
Iowa	18.81	1.23
Kansas	20.60	1.28
Kentucky	22.30	0.93
Louisiana	19.94	1.25
Maine	21.61	3.10
Maryland	16.02	1.25
Massachusetts	11.56	1.33
Michigan	17.83	1.02
Minnesota	16.71	1.20
Mississippi	20.54	1.26
Missouri	21.81	1.62
Montana	33.15	3.31
Nebraska	18.78	1.67
Nevada	34.19	3.46
New Hampshire	19.00	1.71
New Jersey	11.47	0.45
New Mexico	31.48	1.30
New York	11.32	1.05
North Carolina	19.71	0.93
North Dakota	20.45	2.67
Ohio	17.43	0.98
Oklahoma	24.03	1.06
Oregon	25.28	1.73
Pennsylvania	18.88	1.11
Rhode Island	13.25	0.99
South Carolina	19.31	1.15
South Dakota	24.76	3.89
Tennessee	21.93	0.53
Texas	18.59	1.37
Utah	25.51	1.90
Vermont	22.12	2.56
Virginia	19.26	1.32
Washington	21.84	1.45
West Virginia	24.64	2.10
Wisconsin	19.04	0.83
Wyoming	32.29	3.96
United States	21.05	5.64

Source: Centers for Disease Control and Prevention (CDC), and own construction.

Note: The District of Columbia is excluded, since it had essentially banned the possession of handguns during the study years.

Hispanic white (*white*) were obtained from the US Census Bureau.

3.2.2.2. Firearms regulations. In order to maximize variation across states and over time in the measure of gun control, we created three additive indices that reflect different categories of firearms regulations. The first index—arguably is the most important in terms of suicide prevention—measures general prohibitions. It is the sum of two indicator variables reflecting the presence

or absence of permit requirements and prohibitions on firearm purchases by minors. This index thus varies between 0 and 2.

The second index measures prohibitions based on behavioral problems, some of which have been identified as risk factors for suicide. This index is the sum of five indicators variables reflecting the presence or absence of bans on persons with mental health, alcohol, or drug problems, as well as prohibitions on those with prior convictions for misdemeanors and for domestic violence offenses.

Our third and last index captures four types of prohibitions related to the potential purchaser's criminal history. We include this variable primarily as a robustness check, since the prohibitions captured are least likely to affect suicide. The index, varying between 0 and 4, is the sum of indicator variables measuring the presence of prohibitions against "aliens",⁶ convicted felons, fugitives from justice, and those who committed serious offenses as juveniles. Data on state gun regulations was obtained from the Bureau of Justice Statistics.⁷

3.2.2.3. Gun ownership. Given the relationship between firearm regulations and firearm prevalence, as well as that between firearm prevalence and suicide, it is necessary to control for gun ownership. One concern is the accuracy of data on firearm availability. Gun ownership at the household level is measured every several years by the CDC's Behavioral Risk Factor Surveillance System, but there is no annual data at the state level, and the available data only dates back to 2001. The most commonly used proxies for gun ownership are the proportion of homicides and the proportion of suicides committed with firearms (e.g. [36–42]). These variables are combined to create a measure called Cook's index. However, given that the dependent variable for this analysis is the total number of suicides, it was felt that this proxy was inappropriate. As an alternative, the number of hunting licenses per capita from the Fish and Wild Life Service⁸ was used as a control for gun ownership⁹. Hunting licenses per capita and firearm suicides as a proportion of suicides (i.e. Cook's Index) were highly correlated ($r = 0.74$, p -value < .05).

Table 2 reports summary statistics for the variables used in regressions.

4. Results

The regression results for the negative binomial regression model of suicides are presented in **Table 3**. In all regression models, the state and year fixed effects are statistically significant. **Table 3** shows the incidence rate ratios (henceforth, IRR). The IRR are obtained by exponentiation of the regression coefficients, that is, $\exp(\beta)$. The expression $100^*(\exp(\beta) - 1)$ is the percentage change in the

⁶ In some states, this prohibition refers to undocumented immigrants, while in others to individuals who have "forsaken their allegiance to the United States".

⁷ <http://www.ojp.usdoj.gov/bjs/>.

⁸ Available at www.fws.gov.

⁹ The model was also estimated using the firearm suicide proxy, and results were very similar. We do not report them here for brevity.

Table 2Summary statistics ($N=500$).

Variables	Mean	Std. Dev.	Min	Max
<i>Dependent variables</i>				
Male suicides, total	484.09	476.87	49	2939
Male suicide, ages 15–24	70.95	62.67	3	421
Male suicide, ages 25–44	191.06	181.23	18	1191
Male suicide, ages 45–64	134.20	134.80	7	831
Male suicide, ages >65	93.36	102.79	1	575
<i>Socio-economic variables</i>				
Percent with bachelor's degree	24.65	4.67	12.70	38.70
Real per capita income (log)	10.20	0.15	9.82	10.65
Unemployment rate	4.81	1.17	2.20	8.20
Beer consumption per capita (units)	1.27	0.20	0.73	1.91
Percent non-hispanic white (multiply by 100)	0.78	0.15	0.26	0.99
Percent 65 years or older (same)	0.14	0.11	0.05	1.34
<i>Gun supply</i>				
Hunting licenses per capita	0.087	0.071	0.007	0.340
<i>Firearm regulation</i>				
<i>General prohibitions (1)</i>				
Permit requirements	0.22	0.41	0	1
Ban on purchase by minors	0.68	0.47	0	1
General prohibitions index	0.90	0.63	0	2
<i>Behavioral prohibitions (2)</i>				
Mental health problem	0.47	0.50	0	1
Alcohol problem	0.34	0.47	0	1
Drug problem	0.41	0.49	0	1
Misdemeanor conviction	0.36	0.48	0	1
Domestic violence conviction	0.29	0.45	0	1
Behavioral prohibitions index	1.87	1.70	0	5
<i>Criminal prohibitions (3)</i>				
Alien	0.15	0.36	0	1
Felony	0.73	0.45	0	1
Juvenile offense	0.41	0.49	0	1
Fugitive	0.17	0.38	0	1
Criminal prohibitions index	1.46	1.11	0	4

Sources: See text.

incidence or risk of suicide mortality for each unit increase in the independent variable.

The first two models show the effects of fixed state and year effects (Model 1), and the fixed effects in addition to a set of socio-demographic variables—namely education, income, alcohol consumption, the proportion of the population over age 65, and the proportion of the population which is non-Hispanic white (Model 2). Model 3 introduces the index of general prohibitions—namely gun control regulations which affect the largest number of people and which create general barriers to entry. We find the general prohibition index to be statistically significant, both individually and when we include our proxy for gun prevalence, (hunting licenses per capita), which enters insignificantly (Model 4).

The next model includes the second index of gun control measures, which aims to capture firearm restrictions based on behavioral issues such as a history of mental health or alcohol/drug problems. While significant, the IRR is 0.9946, as compared with the IRR from Model 3 which was 0.9440, and the coefficient in Model 4 is only significant at the 10 percent level. The addition of the gun ownership measure (Model 5) does not affect the results. Model 6 includes our last index, which captures gun control measures that are hypothesized to be unlikely to affect suicide. This model

is included primarily as a robustness check. As expected, this variable does not enter with a statistically significant coefficient.

Table 4 shows the effects of the specific firearm restrictions on suicide for particular age groups. Separate models were estimated for males aged 15–24, 25–44, 45–64, and 65 years of age and older. In all models, we control for gun prevalence by including the number of hunting licenses per capita. We find that gun control measures do not affect all age groups identically. For instance, a ban on firearm purchases by minors affects suicides particularly among younger males, while restrictions on permits and waiting period requirements have a more deterrent effect on older males. Unexpectedly, permit requirements appear to have a positive effect on suicide rates among younger males. Among the behavior-related restrictions, prohibitions related to mental health problems are only significant for males aged 25–44 years, and prohibitions related to alcohol problems are only significant for males aged 65 years or older. The drug and misdemeanor conviction bans do not enter significantly for any of the age groups, and the prohibition linked to a history of domestic violence only affects suicides among those aged 45–64 years. None of the criminal prohibitions enter significantly for specific age groups, and are therefore omitted.

Table 3

Results of negative binomial regressions with additive indices of firearm restrictions. Regressions for all males, 1995–2004 ($N=500$). Dependent variable is the number of male suicides, exposure variable is the male population.

	Model 1 Fixed effects only	Model 2 Socio-economic variables	Model 3 General Prohibitions	Model 4 General prohibitions and hunting licenses per capita	Model 5 Behavioral prohibitions	Model 6 Criminal prohibitions
State Fixed Effects	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X
High School graduates (%)		0.9985	0.9991	0.9991	0.9986	0.9984
S.E.		0.0017	0.0017	0.0017	0.0016	0.0017
Beer Consumption per capita		1.1067	1.1022	1.1021	1.1184	1.0988
S.E.		0.1062	0.1039	0.1037	0.1012	0.1011
Unemployment rate		1.0181 **	1.0185 **	1.0185 **	1.0165 **	1.0179 **
S.E.		0.0075	0.0076	0.0075	0.0074	0.0073
Log of median HH income		0.6394 **	0.6433 **	0.6428 **	0.6376 **	0.6375 **
S.E.		0.1424	0.1418	0.1429	0.1338	0.1435
Percent non-Hispanic White		3.5333 ***	3.5115 ***	3.5152 ***	3.3638 ***	3.5250 ***
S.E.		1.5326	1.5247	1.5171	0.0145	1.5327
Percent >65 years		1.1245 ***	1.1232 ***	1.1232 ***	1.1166 ***	1.1261 ***
S.E.		0.0147	0.0153	0.0153	0.0145	0.0157
General prohibitions index (1)			0.9440 ***	0.9438 ***		
S.E.			0.0093	0.0099		
Behavioral prohibitions index (2)					0.9946 *	
S.E.					0.0030	
Criminal prohibitions index (3)						1.0035
S.E.						0.0068
Hunting Licenses Per Capita				0.9692		
S.E.				0.4548		
Log likelihood	-2228.3	-2199.2		-2199.1	-2199.1	-2200.3
Ln alpha	-7.0532	-7.6410	-7.6475	-7.6477	-7.6692	-7.6597
Alpha	0.0009	0.0005	0.0005	0.0005	0.0005	0.0005

Notes: Constant term included but not reported. (1) General prohibitions index: permit requirement, ban on purchase by minor. Range 0–2 (2) Behavioral prohibitions index: mental health, alcohol problems (or intoxication), drug problems, domestic violence conviction, misdemeanor conviction. Range: 0–5. (3) Criminal prohibitions index: alien, prior felony conviction, fugitive from justice, serious offense as a juvenile. Range: 0–4.

* $p < .10$.

** $p < .05$.

*** $p < .01$.

Table 4

Results of negative binomial regressions with individual firearm restrictions. Regressions by age groups (15–24, 25–44, 45–64, 65+) $N=500$. Dependent variable is the number of male suicides, exposure variable is the male population, within age groups.

	Model 1 15–24 years	Model 2 25–44 years	Model 3 45–64 years	Model 4 65+
General prohibitions				
Permit requirement	1.2043 ***	0.9741	0.8601 ***	0.8518 ***
S.E.	0.0343	0.0188	0.0208	0.0222
Ban on minor purchase	0.8715 *	0.8647 ***	0.9867	1.0304
S.E.	0.0679	0.0183	0.0817	0.0756
Behavioral prohibitions				
History of mental health problems	0.9949	0.9657 ***	0.9948	1.0435
S.E.	0.0245	0.0111	0.0212	0.0246
History of alcohol abuse	1.0015	1.0085	0.9916	0.9437 ***
S.E.	0.0199	0.0168	0.0196	0.0166
History of drug abuse	0.9723	0.9972	1.0017	1.0086
S.E.	0.0229	0.0167	0.0220	0.0241
Misdemeanor conviction	1.0169	0.9848	0.9758	1.0062
S.E.	0.0216	0.0159	0.0160	0.0293
Domestic violence conviction	0.9812	1.0048	0.9630 **	0.9700
S.E.	0.0261	0.0190	0.0167	0.0185

Note: All models include state and year fixed effects, as well as control variables for the level of education, unemployment rate, income per capita, and the percent of non-Hispanic white population. A proxy for gun prevalence (hunting licenses per capita) is also included. Constant term included but not reported.

* $p < .10$.

** $p < .05$.

*** $p < .01$.

5. Discussion

Restricting access to lethal means is an important element in suicide prevention. While means restriction activities are not solely focused on firearms, in the United States, firearms are the most significant suicide mechanism, as they are used in more than half of suicides. At the individual and population levels, a number of means restriction activities have been developed to prevent suicides by reducing access to lethal means. Individual activities involve counseling to high-risk individuals about dangers posed by a firearm in their homes. When such activities occur, they are usually directed at individuals who have been identified as being at risk of self-injury, perhaps as a result of a non-fatal suicide attempt. However from a population perspective, gun control remains one of the only avenues to restrict access to firearms.

Our study suggests that general barriers to firearm access created through state regulation can have a significant effect on male suicide rates in the United States. Permit requirements and bans on sales to minors were the most effective of the regulations analyzed. These findings have important implications for U.S. gun control policy, which remains exceptionally heterogeneous across states. While all states except Wyoming have banned sales of handguns to minors, twelve states still allow the sale of long guns to minors. Furthermore, only twelve states currently require purchase permits for firearms.

The political aspect of the gun control debate in the United States has made increased regulation of firearms very difficult in many states, due to the strong advocacy of the gun rights lobby, and the opposition to any restriction on gun ownership by many gun owners. Many of the more controversial aspects of firearms regulations battles concern provisions intended to reduce crime, such as bans on “straw purchases”, or limits on the number of guns individuals can purchase in a year. The relationship between firearm prevalence and suicide, while well known in the public health community, rarely if ever enters into the national or state debates over gun control provisions. In very recent years, guns rights groups have made significant gains, most notably in the Supreme Court decision regarding handgun bans in the District of Columbia (*District of Columbia v. Heller*, 2008). These trends do not bode particularly well for increased regulation of gun ownership in U.S. states. However, while gun control remains a controversial issue both at the state and federal level in the U.S., this analysis of male suicide suggests that there are clear public health benefits to restricting access to firearms through regulation.

Conflict of interest

The authors have no conflicts of interest.

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