HEALTH CARE REFORM

Firearm Legislation and Firearm-Related Fatalities in the United States

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Importance: Over 30 000 people die annually in the United States from injuries caused by firearms. Although most firearm laws are enacted by states, whether the laws are associated with rates of firearm deaths is uncertain.

Objective: To evaluate whether more firearm laws in a state are associated with fewer firearm fatalities.

Design: Using an ecological and cross-sectional method, we retrospectively analyzed all firearm-related deaths reported to the Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System from 2007 through 2010. We used state-level firearm legislation across 5 categories of laws to create a "legislative strength score," and measured the association of the score with state mortality rates using a clustered Poisson regression. States were divided into quartiles based on their score.

Setting: Fifty US states.

Participants: Populations of all US states.

Main Outcome Measures: The outcome measures were state-level firearm-related fatalities per 100 000 individuals per year overall, for suicide, and for homicide. In various models, we controlled for age, sex, race/ethnicity, poverty, unemployment, college education, population density, nonfirearm violence–related deaths, and household firearm ownership.

Results: Over the 4-year study period, there were 121 084 firearm fatalities. The average state-based firearm fatality rates varied from a high of 17.9 (Louisiana) to a low of 2.9 (Hawaii) per 100 000 individuals per year. Annual firearm legislative strength scores ranged from 0 (Utah) to 24 (Massachusetts) of 28 possible points. States in the highest quartile of legislative strength (scores of ≥9) had a lower overall firearm fatality rate than those in the lowest quartile (scores of ≤2) (absolute rate difference, 6.64 deaths/100 000/y; age-adjusted incident rate ratio [IRR], 0.58; 95% CI, 0.37-0.92). Compared with the quartile of states with the fewest laws, the quartile with the most laws had a lower firearm suicide rate (absolute rate difference, 6.25 deaths/100 000/y; IRR, 0.63; 95% CI, 0.48-0.83) and a lower firearm homicide rate (absolute rate difference, 0.40 deaths/100 000/y; IRR, 0.60; 95% CI, 0.38-0.95).

Conclusions and Relevance: A higher number of firearm laws in a state are associated with a lower rate of firearm fatalities in the state, overall and for suicides and homicides individually. As our study could not determine cause-and-effect relationships, further studies are necessary to define the nature of this association.

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THE TOTAL NUMBER OF ANnual firearm fatalities in the United States has been stable over the last decade.[1,2] From 2007 to 2010, the range was 31 224 to 31 672 fatalities per year.[1] There is substantial variation in firearm fatality rates among states, however, with the average annual state-based firearm fatality rates ranging from a high of 17.9 (Louisiana) to a low of 2.9 (Hawaii) per 100 000 individuals during these years. In 2010, firearms killed 68% of the 16 259 victims of homicide. In the same year, there were 38 364 suicides, of which 51% were by firearms.[1] Beyond the loss of life and nonfatal traumatic injuries, the financial cost of firearm injuries is enormous. In 2005, the medical costs associated with fatal and nonfatal firearm injuries were estimated at $112 million and $599 million, respectively, and work loss costs were estimated at $40.5 billion.[1]

See Invited Commentary at end of article

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Mass killings such as those in Columbine and Aurora in Colorado, the Wisconsin Sikh temple shooting, and most recently the Newtown, Connecticut, school massacre have renewed debate about the need for more stringent firearm legislation. Some have called for more restrictions on gun purchases.[3] Others have called for arming teachers.[4] It is challenging to calculate the exact number of firearm laws: a single law may have multiple parts; laws are potentially passed at the national, state, county, and city level; and there is no repository available for tallying these laws.[5] The factoid that there are "20 000 laws governing firearms"[5] has been erroneously quoted since 1965, but the most recent and reliable estimate, performed in 1999, counted about 300 state firearm laws.[6]

The real question is not about the number of firearm laws but whether the laws ultimately safeguard the citizens they are intended to protect. Although multiple studies have examined the relationship between federal and state firearm laws and homicide and suicide rates, the overall association between firearm legislation and firearm mortality is uncertain and remains controversial.[7,8]

We evaluated whether variations in the strength of state firearm legislation are associated with variations in the rates of firearm fatalities. We examined overall firearm death rates as well as firearm suicide and firearm homicide rates by state, controlling for other factors previously associated with firearm fatalities.

METHODS

The Boston Children's Hospital institutional review board approved the study.

DATABASE

We used data from the Web-Based Injury Statistics Query and Reporting System (WISQARS),[1] which provides mortality tables with the numbers of injury-related deaths and mortality rates according to cause (mechanism) and intent of injury (unintentional, violence-related [including homicide and suicide], or undetermined) by year, sex, age, race/ethnicity, and state. These mortality data are compiled by the National Center for Health Statistics, Centers for Disease Control and Prevention (CDC) from multiple cause of death data. The federal government mandates that each state provide information about deaths that occur within its border.[9] Mortality data on nonfirearm intentional deaths (suicides and homicides) were also obtained from WISQARS.

STUDY POPULATION

We identified all violence-related firearm fatalities between January 2007 and December 2010, and used data on age-adjusted firearm mortality, including suicides (60.9% of firearm-related fatalities) and homicides (39.1% of firearm-related fatalities). Homicides due to legal intervention, unintentional firearm fatalities, and fatalities of undetermined intent (1.1%, 1.9%, and 0.8% of total firearm-related fatalities, respectively) were excluded from the analyses.

STATE-LEVEL FACTORS

We studied all 50 states. To quantify state-level variation in gun regulations, we used data from the Brady Campaign to Prevent Gun Violence[10] and the Brady Center to Prevent Gun Violence (referred to collectively herein as *the Brady Center*). Working with the Law Center to Prevent Gun Violence (formerly Legal Community Against Violence), the Brady Center has tracked firearm legislation annually since 2007 and prepared legislative scorecards for every state each year. It divides firearm legislation into 5 categories according to the intended effect: (1) curb firearm trafficking; (2) strengthen background checks on purchasers of firearms beyond those required by the Brady Handgun Violence Prevention Act; (3) ensure child safety; (4) ban military style assault weapons; and (5) restrict guns in public places (**Table 1**). The Brady Act, which went into effect in 1994, requires background checks of potential buyers before a firearm may be purchased from a federally licensed dealer, manufacturer, or importer. Firearm sales are prohibited to convicted felons and fugitives. They are also prohibited to persons with a history of addiction to controlled substances, persons restrained by court order against harassment, those convicted of domestic violence, and those adjudicated as "mentally defective," among other groups. The Brady Center's fifth category, restricting guns in public places, refers to the absence of laws that would allow guns in public places.

For our primary analysis, we used a simplified approach to create a "legislative strength score" for each state. The legislative strength score was developed before the analyses were conducted. Each state could have enacted up to 28 laws; each enacted law received 1 point. This "1 law = 1 point" score gives each law equal weight. However, the Brady Center also prepares an empirical weight schema for each set of laws, scaling the scores out of 100 points and giving additional weight to laws believed to be more important. In their weighted scoring system, the "strengthen Brady background checks" category (which includes requiring universal background checks on all firearm purchases no matter who sells the firearm and requiring permits to purchase firearms) receives the greatest number of points. We separately analyzed the data using this weighted scoring system. A detailed description of each of the laws and the weighted scoring system is available from the Brady Center.[10]

We used US Census data to capture state-level statistics on factors and characteristics previously shown to be associated with firearm fatalities: race/ethnicity (white, black, Hispanic), sex, living below the federal poverty level, unemployment, college education, and state population density.[8] In addition, we calculated household firearm ownership rates per state using the firearm suicide/total suicide ratio, which is the proportion of all suicides in a state caused by firearms.[11] This ratio has been highly correlated with firearm ownership rates in the United States and other developed nations.[12-17] There are no direct data from 2007 through 2010 on firearm ownerships rates in the United States; the last large state-based survey of firearm ownership was performed in 2004 by the CDC's Behavioral Risk Factor Surveillance System.

OUTCOME MEASURES

Our primary outcome measures were overall firearm-related fatality rates per 100 000 individuals per year. The rates for firearm suicides and firearm homicides were considered separately.

DATA ANALYSIS

First, we obtained the number of firearm-related suicides and firearm-related homicides for each state. We calculated death rates by dividing the total number of deaths by the state populations each year and adjusting for age. We then divided states into quartiles based on their legislative strength score, with quar-

Table 1. Scoring System for Firearm Legislative Strength Score[a]

Legislation Intent	Description of Measures
Curb firearm trafficking (9 points)	
Gun dealer regulations (6 points)	State license required for firearm dealers
	Record keeping and retention by firearm dealers
	Report records to the state, and state retains records
	Mandatory theft reporting for all firearms by firearm dealers
	At least 1 store security precaution required
	Inspections by police allowed/required to inspect dealer inventories
Limit bulk purchases (1 point)	One handgun per month (exceptions possible)
Crime gun identification (1 point)	Ballistic fingerprinting or require microstamping on semi-automatic handguns
Report lost/stolen guns (1 point)	Mandatory reporting by firearm owners
Strengthen Brady background checks (8 points)	
Universal background check[b] (1 point)	All firearms
	Handguns only
Closed gun show loophole[c] (1 point)	Background check on firearm purchasers at gun shows
Permit to purchase (5 points)	Permits required to purchase firearms
	Fingerprinting of applicants required for identification
	Safety training and/or testing required
	Extend three-day limit for background checks
	Permit process involves law enforcement
Ammunition regulations (2 points)	Ammunition purchaser records kept/vendor license required
	Ammunition Brady check/permit required to purchase
Improve child safety (5 points)	
Childproof handguns (1 point)	Only authorized users are able to operate new handguns
Child safety locks[d] (2 points)	Integrated locks sold on all handguns
	External locks sold with all handguns
	Standards on all external locks – child safety locks certified
Child access prevention[e] (1 point)	Adults must store loaded guns in inaccessible place or lock the gun
Juvenile handgun purchases (1 point)	Must be 21 to purchase a handgun
Ban military-style assault weapons (2 points)	
Assault weapons ban (2 points)	Regulation of firearms with military-style features
	Maximum number of rounds per magazine 15 or less
Restrict guns in public places[f] (4 points)	
No guns in workplace (1 point)	Employers not required to allow firearms in parking lots
No guns on college campuses (1 point)	Colleges are not required to allow firearms on campus
Not carrying a concealed weapon shall issue state (1 point)	Law enforcement is not required to issue a permit to carry a concealed weapon to all individuals who can legally own a firearm
No state preemption of local laws (1 point)	Local governments can enact firearm laws and regulations that are stricter than state laws
Overall possible points, 28	

[a] Table data source, Brady Center State Scorecards.[10]
[b] States receive a point for background checks on either all firearms or handguns only.
[c] States with universal background checks on all firearms not eligible for gun show loophole points.
[d] One point for either integrated or external locks.
[e] If a child in the specified age ranges obtains a stored, loaded gun, the adult owner may be held criminally liable. Any age category receives credit: 16 to 17 years or younger, 14 to 15 years or younger, or 13 years or younger.
[f] Points assigned for restriction of guns in public places to trained law enforcement and security and preserve local control over municipal gun laws.

tile 1 including the states with the lowest scores and quartile 4, the states with the highest scores.

Our study design used an ecological and cross-sectional method. To evaluate the association of firearm-related fatalities (overall, suicide, and homicide) with the legislative strength score as the main predictor,[12] we constructed 3 models for each outcome. In model 1, we computed a Poisson regression, adjusting for age, to evaluate the association between the annual score and firearm fatality rates without further adjustments. In model 2, to account for other socioeconomic factors associated with firearm fatalities, we used a multivariable Poisson regression to adjust for age, race/ethnicity, sex, poverty, unemployment, college education, population density, and rates of nonfirearm suicides and/or nonfirearm homicides. In model 3 we added household firearm ownership rates to the variables included in model 2. Across all 3 models, we analyzed the firearm suicide data by year. Overall firearm-related fatalities and homicide fatalities were aggregated at the state level over the entire 4-year study period: the small numbers of firearm homicides in 12 states precluded the availability of annual data. These aggregate data were divided to derive a mean annual fatality rate. To evaluate whether weighting the relative significance of specific laws would alter the association of the legislative strength score with firearm fatalities, we ran the multivariable model 2 with the quartiles derived from the weighted

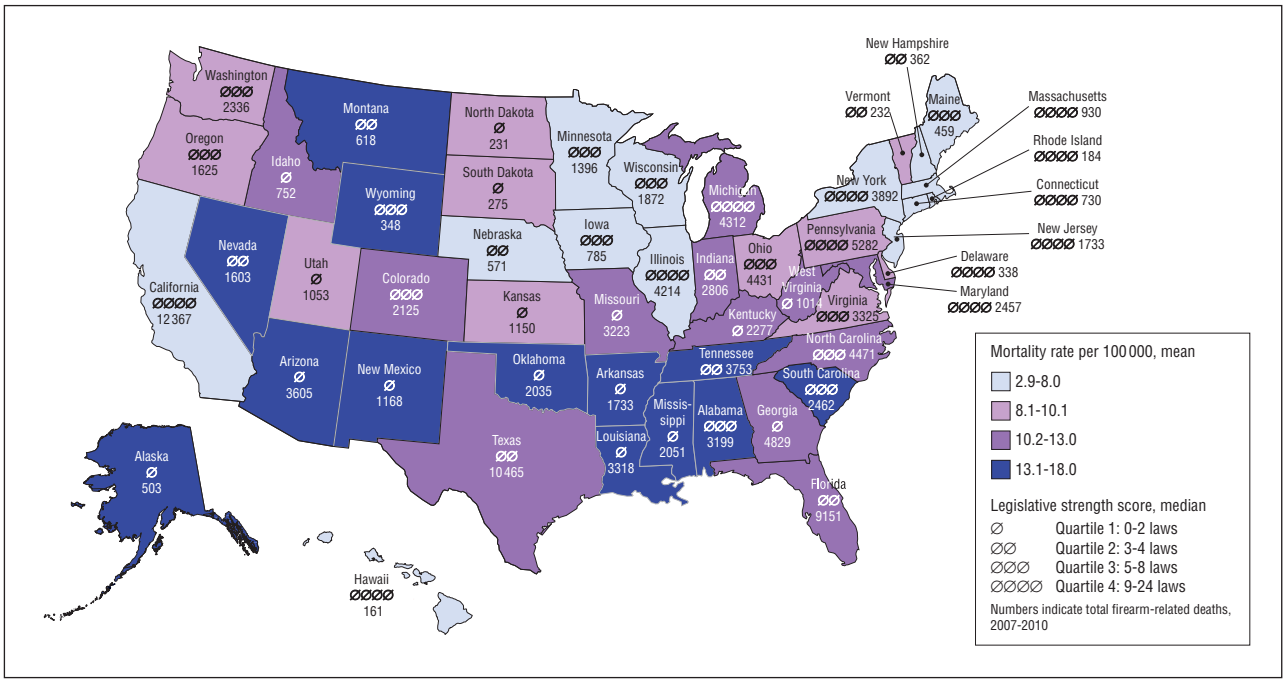

Figure 1. Firearm-related mortality rates, legislative strength scores, and total firearm deaths in the United States, 2007 through 2010.

Brady score as a separate analysis.[10] We present age-adjusted absolute rate differences, referenced to quartile 1.

To further explore whether some legislative categories may have a greater association with firearm fatalities than other legislative categories, we created a multivariable Poisson regression to evaluate the association of each of the 5 categories of legislation with firearm fatality rates (overall, suicide, and homicide). Similar to model 2, we adjusted for socioeconomic factors and nonfirearm suicides and/or homicides. For all modeling, we used clustered robust sandwich standard error estimates, which allow for intrastate correlation, relaxing the assumption that observations from the same state are independent.

Firearm ownership rates have been associated with firearm suicide and firearm homicide rates in other studies.[8,18] We hypothesized that an important way in which legislation might affect the firearm fatality rate in a state is through changes in firearm prevalence. For example, laws requiring background checks for all gun purchases or raising the purchase age to 21 can be expected to reduce firearm ownership rates. To explore this hypothesis, we conducted a stepwise analysis of firearm ownership. First, we examined the association of the legislative strength score with firearm ownership rates using a simple linear regression with firearm ownership rates as the outcome and the score as the predictor. Then, using simple linear regression, we evaluated whether household firearm ownership rates were associated with overall firearm fatality rates. Then we reanalyzed our multivariable model 3 with linear regression and evaluated the effect of firearm ownership rates on the legislative strength score and overall firearm fatalities using the Sobel-Goodman test.[19,20]

Finally, we examined whether differences between states in their rates of firearm-related fatalities were owing to a replacement effect, ie, the possibility that lower rates of firearm-related fatalities were being replaced with higher rates of nonfirearm-related violent fatalities. We controlled for nonfirearm suicide rates in the suicide regression and for nonfirearm homicide rates in the homicide regression. We performed a Poisson regression with nonfirearm violent fatalities as the outcome and firearm fatalities as the predictor. In addition, we used Poisson regression to evaluate the relationship between legislative strength scores and nonfirearm-related violent fatalities. If these fatalities were associated with firearm legislation, it would suggest that other unmeasured factors affected the rates of both firearm- and nonfirearm-related fatalities.

All of the data analyses were performed using STATA SE, version 11 (StataCorp).

RESULTS

Between 2007 and 2010, there were 121 084 firearm fatalities in the United States, including 73 702 firearm suicides and 47 382 firearm homicides. The overall firearm fatality rate was 9.9/100 000 individuals per year. The variation between the highest and lowest state-level mortality rates was up to a 6-fold difference (**Figure 1** and **Table 2**). Firearm legislative strength scores per year by state ranged from 0 (Utah) to 24 (Massachusetts) of 28 possible points, with some variation by year (Table 2). The median and range for each legislative strength score quartile were as follows: first quartile, 2 (0-2); second quartile, 3 (3-4); third quartile, 6 (5-8); and fourth quartile, 16 (9-24).

The simple regression model demonstrated that higher legislative strength scores were associated with lower rates of firearm fatalities overall ($P < .001$) (**Figure 2**A). In the multivariable overall fatality Poisson model, which controlled for state-specific socioeconomic and demographic factors, we found that compared with the referent group of the quartile with the fewest laws, the quartile of states with the most laws had an absolute rate difference of 6.64 deaths/100 000 per year, with an adjusted incident rate ratio (IRR) of 0.58 (95% CI, 0.37-0.92). In the multivariable suicide model, compared with the referent, the quartile with the most laws had an absolute rate difference of 6.25 deaths/100 000 per year, with an adjusted IRR of 0.63 (95% CI, 0.48-0.83). In the multivari-

Table 2. State Legislative Strength Scores and Firearm Fatality Rates per 100 000 Individuals per Year, 2007-2010[a]

Rank	State	Legislative Strength Score, Median (Range)[b]	Firearm Fatalities, Mean (SD)		
			Overall	Suicide	Homicide
1	Massachusetts	22.5 (22-24)	3.4 (0.42)	1.7 (0.31)	1.7 (0.18)
2	California	22 (22-23)	8.0 (0.45)	4.0 (0.06)	4.0 (0.45)
	New Jersey	22 (22-24)	4.9 (0.19)	1.9 (0.04)	3.0 (0.27)
4	Connecticut	20 (19-20)	5.1 (0.76)	2.6 (0.40)	2.5 (0.39)
5	New York	19 (19-19)	4.8 (0.18)	2.1 (0.10)	2.7 (0.06)
6	Hawaii	16 (15-16)	2.9 (0.44)	2.3 (0.39)	0.7 (0.08)
	Maryland	16 (15-17)	10.5 (1.20)	4.1 (0.35)	6.3 (1.00)
8	Rhode Island	14 (13-14)	4.1 (0.61)	2.6 (0.70)	1.5 (0.25)
9	Illinois	11.5 (11-12)	7.9 (0.18)	3.3 (0.15)	4.7 (0.22)
10	Michigan	11 (10-11)	10.6 (0.05)	5.6 (0.22)	5.1 (0.22)
11	Delaware	9 (8-9)	9.5 (1.10)	4.6 (0.34)	4.8 (1.20)
12	Pennsylvania	8.5 (8-9)	10.1 (0.24)	5.7 (0.25)	4.3 (0.27)
13	Alabama	8 (8-8)	16.3 (0.73)	9.0 (0.64)	7.2 (0.99)
	North Carolina	8 (7-8)	11.7 (0.44)	7.0 (0.27)	4.6 (0.56)
	Virginia	8 (8-8)	10.1 (0.28)	6.5 (0.33)	3.4 (0.30)
	Washington	8 (8-9)	8.4 (0.12)	6.6 (0.29)	1.8 (0.10)
17	Iowa	7 (3-7)	6.2 (0.87)	5.2 (0.72)	0.9 (0.30)
18	Minnesota	6 (5.6)	6.4 (0.33)	5.2 (0.18)	1.2 (0.22)
	Oregon	6 (6-6)	9.9 (0.64)	8.5 (0.51)	1.3 (0.19)
20	Colorado	5 (5-5)	10.3 (0.54)	8.3 (0.47)	2.1 (0.16)
	Maine	5 (5-5)	8.0 (0.44)	6.8 (0.58)	1.1 (0.09)
	Ohio	5 (4.5)	9.1 (0.70)	5.5 (0.51)	3.6 (0.19)
	South Carolina	5 (5-6)	13.0 (0.24)	7.5 (0.64)	5.4 (0.29)
	Wisconsin	5 (4-5)	8.0 (0.45)	6.0 (0.24)	1.9 (0.34)
	Wyoming	5 (4-5)	15.5 (1.80)	14.6 (1.50)	1.3 (0.004)
26	Georgia	4 (4-5)	12.2 (0.37)	7.2 (0.56)	5.1 (0.58)
	Nebraska	4 (3-4)	7.6 (0.56)	5.2 (0.28)	2.3 (0.40)
	New Hampshire[c]	4 (3-4)	6.4 (0.51)	6.0 (0.86)	NA
	Tennessee	4 (4-4)	14.3 (0.54)	8.9 (0.34)	5.3 (0.44)
	Vermont[c]	4 (4-4)	8.7 (0.75)	7.8 (1.50)	NA
31	Florida	3 (3-4)	11.8 (0.45)	6.9 (0.33)	4.8 (0.48)
	Indiana	3 (2-3)	10.5 (0.36)	6.7 (0.40)	3.8 (0.21)
	Mississippi	3 (3-3)	16.8 (1.10)	9.3 (0.55)	7.4 (0.68)
	Nevada	3 (3-3)	14.9 (0.73)	10.9 (0.35)	3.9 (0.78)
	Texas	3 (3-3)	10.5 (0.21)	6.6 (0.33)	3.9 (0.28)
36	Montana	2.5 (2-3)	14.8 (0.48)	12.8 (0.72)	1.8 (0.41)
37	Arkansas	2 (2-2)	14.5 (0.78)	9.1 (0.52)	5.3 (0.44)
	Kansas	2 (2-4)	9.9 (0.58)	7.0 (0.47)	2.8 (0.41)
	Missouri	2 (2-2)	13.0 (0.56)	7.4 (0.43)	5.5 (0.67)
	North Dakota[c]	2 (2-2)	8.4 (0.16)	7.9 (0.48)	NA
	New Mexico	2 (2-2)	13.8 (0.22)	9.6 (0.26)	4.2 (0.33)
	South Dakota	2 (2-2)	8.2 (1.50)	7.3 (1.50)	0.9 (0.02)
	West Virginia	2 (2-2)	12.7 (1.30)	9.9 (0.88)	2.7 (0.45)
44	Arizona	1.5 (1-2)	13.6 (0.68)	8.9 (0.57)	4.8 (0.89)
	Idaho	1.5 (1-2)	11.8 (0.85)	10.8 (1.00)	1.1 (0.62)
46	Alaska	1 (1-1)	17.5 (2.80)	14.4 (2.70)	3.2 (0.87)
	Kentucky	1 (1-1)	12.6 (0.71)	9.2 (0.36)	3.3 (0.41)
	Louisiana	1 (1-2)	18.0 (0.85)	7.8 (0.54)	10.1 (0.73)
	Oklahoma	1 (1-1)	13.4 (0.41)	9.4 (0.58)	4.0 (0.33)
50	Utah	0.5 (0-1)	9.8 (1.30)	8.8 (1.30)	1.1 (0.19)

Abbreviations: CDC, Centers for Disease Control and Prevention; NA, not available.

[a] Data are from the WISQARS (Web-based Injury Statistics Query and Reporting System)[1] and the legislative strength score.

[b] Legislative strength score is the median of the annual scores for 2007 through 2010. The highest legislative strength score received the lowest rank. States with the same legislative strength score are listed in alphabetical order within that score.

[c] State with a low number of annual deaths (<20) from homicide. Mean rate was not available from CDC.

able homicide model, compared with the referent, the quartile with the most laws had an absolute rate difference of 0.40 deaths/100 000 per year, with an adjusted IRR of 0.60 (95% CI, 0.38-0.95) (**Table 3**). In the models including firearm availability, an increased legislative strength score trended in the direction of lower firearm homicides but was significant only in quartile 3. Controlling for firearm availability attenuated the association between legislative strength score and firearm suicide. When the Brady Center weighted scores were used as the predictor in the models, the IRRs did not substantially change (data not shown).

For the specific legislative categories, only background checks had a significant relationship across all

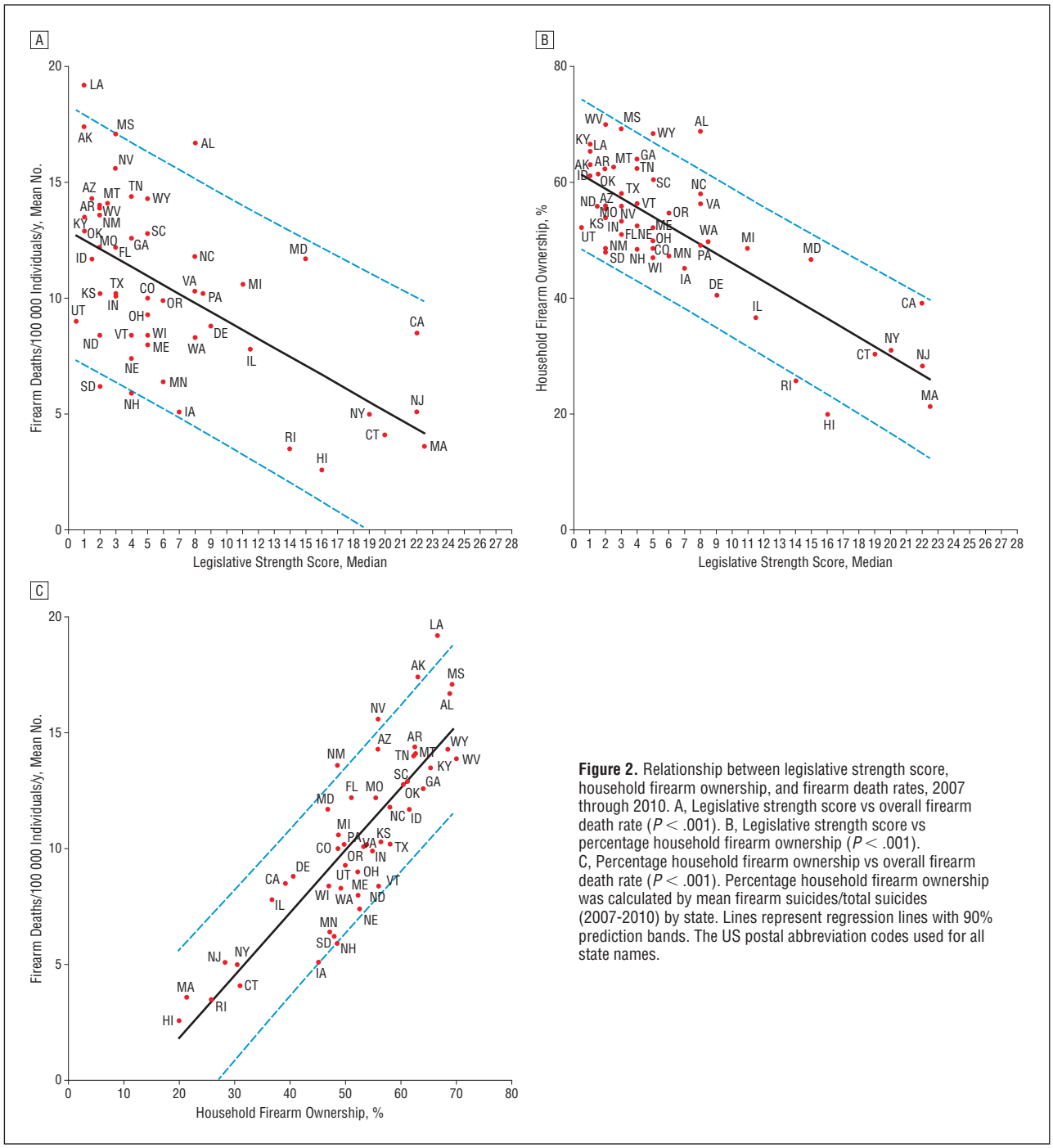

Figure 2. Relationship between legislative strength score, household firearm ownership, and firearm death rates, 2007 through 2010. A, Legislative strength score vs overall firearm death rate ($P < .001$). B, Legislative strength score vs percentage household firearm ownership ($P < .001$). C, Percentage household firearm ownership vs overall firearm death rate ($P < .001$). Percentage household firearm ownership was calculated by mean firearm suicides/total suicides (2007-2010) by state. Lines represent regression lines with 90% prediction bands. The US postal abbreviation codes used for all state names.

outcomes, with stronger background checks associated with lower overall firearm fatality rates: a 1-point increase in the background check category had an adjusted IRR of 0.84 (95% CI, 0.78-0.92), lower firearm suicide fatality rates (adjusted IRR, 0.90; 95% CI, 0.87-0.94), and lower firearm homicide fatality rates (adjusted IRR, 0.91; 95% CI, 0.84-0.99) (**Table 4**).

Higher legislative strength scores were associated with lower household firearm ownership ($P < .001$) (Figure 2B). Higher percentage of household firearm ownership was associated with higher rates of overall firearm fatalities ($P < .001$) (Figure 2C). The Sobel-Goodman test of mediation demonstrated a significant effect of firearm ownership on the relationship between the legislative strength score and overall firearm fatalities ($P < .001$).

The simple Poisson regression demonstrated no association between firearm-related deaths and nonfirearm violent deaths ($P = .50$). There was also no association between legislative strength scores and nonfirearm violence–related deaths ($P = .20$).

COMMENT

In an analysis of all states using data from 2007 through 2010, we found that a higher number of firearm laws in

Table 3. Change in Firearm Fatality Rates by Legislative Strength Quartile

Legislative Strength Quartile	Absolute Rate Difference[b,c]	Incident Rate Ratio (95% CI)[a]		
		Model 1[c]	Model 2[d]	Model 3[e]
		Overall Firearm Fatalities[f]		
1 (0-2 laws)	0 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
2 (3-4 laws)	1.48	0.88 (0.74-1.06)	0.92 (0.74-1.10)	0.95 (0.88-1.02)
3 (5-8 laws)	2.96	**0.77 (0.63-0.93)**	0.88 (0.65-1.19)	0.89 (0.79-1.00)
4 (9-24 laws)	6.64	**0.48 (0.36-0.65)**	**0.58 (0.37-0.92)**	1.00 (0.83-1.21)
		Firearm Suicide		
1 (0-2 laws)	0 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
2 (3-4 laws)	1.17	**0.85 (0.73-0.99)**	0.94 (0.82-1.08)	0.97 (0.94-1.00)
3 (5-8 laws)	2.52	**0.78 (0.65-0.93)**	0.94 (0.78-1.14)	0.99 (0.95-1.01)
4 (9-24 laws)	6.25	**0.34 (0.26-0.43)**	**0.63 (0.48-0.83)**	0.97 (0.92-1.02)
		Firearm Homicide[f]		
1 (0-2 laws)	0 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
2 (3-4 laws)	0.31	0.91 (0.57-1.46)	0.89 (0.71-1.12)	0.83 (0.68-1.08)
3 (5-8 laws)	0.44	0.88 (0.52-1.48)	0.69 (0.46-1.04)	**0.65 (0.46-0.93**
4 (9-24 laws)	0.40	0.89 (0.54-1.47)	**0.60 (0.38-0.95)**	0.79 (0.49-1.26)

[a] Change in firearm fatality rate represented by the incident rate ratio with reference to quartile 1; boldface type indicates a confidence interval that does not overlap 1.
[b] Absolute rate differences are per 100 000 individuals per year with reference to quartile 1.
[c] Absolute rate differences and model 1 are both age adjusted.
[d] Model 2 is adjusted for age and for control variables (state population density; nonfirearm violence–related fatalities; and percentage of the study population that was male, white, black, Hispanic, in poverty, unemployed, and college educated).
[e] Model 3 is adjusted for age and all control variables, including household firearm ownership.
[f] Data aggregated over 4 years for analysis.

Table 4. Change in Overall Firearm Fatality Rates Associated With 1-Point Increase in Each Legislative Category[a]

Legislative Category	Overall Firearm Fatalities[b]		Firearm Suicide		Firearm Homicide[b]	
	Absolute Rate Difference[c]	IRR (95% CI)[d]	Absolute Rate Difference[c]	IRR (95% CI)[d]	Absolute Rate Difference[c]	IRR (95% CI)[d]
Firearm trafficking	6.67	1.01 (0.96-1.07)	6.22	1.01 (0.97-1.05)	0.46	0.99 (0.92-1.06)
Strengthen Brady checks[e]	9.80	**0.84 (0.78-0.92)**	9.42	**0.90 (0.87-0.94)**	0.41	**0.91 (0.84-0.99)**
Child safety	5.52	0.87 (0.75-1.00)	5.84	**0.86 (0.78-0.95)**	−0.32	1.01 (0.89-1.13)
Ban assault weapons	6.35	**0.73 (0.59-0.90)**	5.37	**0.77 (0.67-0.89)**	0.97	0.84 (0.66-1.07)
Guns in public places[f]	6.35	**0.88 (0.77-0.99)**	6.61	**0.91 (0.82-0.99)**	−0.26	0.94 (0.82-1.09)

Abbreviations: IRR, incident rate ratio; US postal code abbreviations used to indicate individual US states.
[a] The models are adjusted for age and for control variables (state population density; nonfirearm violence–related fatalities; and percentage of the study population that was male, white, black, Hispanic, in poverty, unemployed, and college educated); bold type indicates a confidence interval that does not overlap 1.
[b] Data aggregated over 4 years for analysis.
[c] Absolute rate difference between states with lowest score and those with highest score in given legislative category. Rates are age adjusted and reflect the number per 100 000 individuals per year. Low and high scores in the given categories are as follows: Firearm trafficking low, 0 (20 states); high, 7-8 (CA, MA, and NJ). Strengthen Brady checks low, 0 (33 states); high, 6-7 (CT, HI, MA, and NJ). Child safety low, 0 (21 states); high, 4-5 (CA, MD, MA, and NJ). Ban assault weapons low, 0 (43 states); high, 2 (CA, HI, MA, NJ, and NY). Guns in public places low, 0-1 (10 states); high, 4 (CA, CT, HI, IL, MA, NJ, and NY).
[d] Change in firearm fatality rates, represented by the IRR, between scores 1 point apart in a specific legislative category.
[e] This includes universal background checks and permits to purchase. See Table 1 for further details.
[f] States that do not have laws that allow guns in public places. See Table 1.

a state was associated with a lower rate of firearm fatalities in the state. This association was present both before and after controlling for other state-specific and socioeconomic factors. Although the results across quartiles 2 through 4 of the legislative strength score demonstrated lower firearm fatalities, these results were only significant when the states with the highest scores were compared with those with the lowest scores. It is important to note that our study was ecological and cross-sectional and could not determine cause-and-effect relationship.

Previous studies evaluating the association of firearm legislation and reducing firearm injuries and fatalities in the United States have had mixed results. Most of the studies focused on specific laws, not the aggregate effect of all laws.[21] For example, a study evaluating the Brady Act, which mandates background checks for firearm purchases, found that suicide rates among persons 55 years or older were reduced, but there were no other differential effects of the law.[22] Despite the law's intent, background checks are relatively easily thwarted at gun shows, flea markets, and elsewhere, where a person who would otherwise be prohibited from purchasing firearms can purchase a gun from a private seller without a background check.[23,24]

Studies that have examined the cumulative impact of firearm legislation, rather than single laws, have often focused on the association of legislation and suicide.[25,26] Conner and Zhong,[27] using data across all 50 states from 1999 to 2000, demonstrated that more restrictive firearm laws were associated with lower rates of suicide. Price et al,[12] using data from 1999 across all 50 states, also found a strong association between restrictiveness of gun laws and firearm suicide but little association with firearm homicide. The association with firearm suicide was not significant after adjusting for household gun ownership levels.[12]

Another important factor affecting suicide is whether guns are stored safely in the home. Guns are the most common method of suicide overall[1] and teen suicide in particular,[28,29] and increased accessibility to loaded, unlocked guns is associated with an increased risk of suicide.[30-33] A case-control study found that safe gun storage practices, which can be required by state law, were associated with a decreased risk of teen suicide and unintentional firearm injuries.[34]

One way that firearm legislation may act to reduce firearm fatalities is through reducing firearm prevalence.[35] Studies have shown a strong connection between gun ownership and firearm suicide[8,36] and firearm homicide.[37] A cross-sectional study of all 50 states from 2001 to 2003 found that higher rates of household firearm ownership were associated with significantly higher rates of homicide.[38] Similarly, rates of suicide are higher in states with greater rates of household firearm ownership.[39]

Although our study found an association between legislation strength, firearm availability, and overall firearm fatalities, the nature of this association should be further characterized. Within a state, culture and attitudes toward firearms may confound the association between firearm ownership and firearm legislation. High levels of gun ownership might be related to both high rates of firearm deaths and a cultural environment in which it is more difficult for a state to enact strict firearm laws. Firearm ownership may also be a mediator of the relationship between the legislative strength score and overall fatalities. The change in the coefficients in the model after the inclusion of household gun ownership rates is consistent with both mediation and confounding.

As is not surprising in a cross-sectional ecological study, we found some heterogeneity in the firearm fatality rates among the states within each level of the legislative strength scores (eg, South Dakota has weak gun control laws and low rates of firearm fatality). Such heterogeneity is to be expected and is the reason to conduct a study that involves all 50 states.

Our study has limitations. First, the legislative strength score, which tallies a single point per law, has not been validated. Neither has the weighted Brady scoring system, and we are unaware of any such scoring systems that have been validated. Our results, which divided states into quartiles of legislative strength, were essentially the same with either of these scoring systems. Second, we examined only deaths by firearms, not nonfatal firearm injuries; fatality was our primary outcome. Approximately 2.6 nonfatal firearm injuries are treated for every fatal firearm injury.[1,40] Third, we were unable to control for the enforcement of firearm laws or the exploitation of loopholes, which may vary between states. Fourth, although we adjusted for many state-based factors associated with firearm fatalities, there may be additional factors not considered in our model that are relevant (eg, city laws and police enforcement). However, we included nonfirearm suicides and nonfirearm homicides in some of our analyses to control for the potential role of additional factors. We found little evidence of substitution—rates of firearm-related deaths were not correlated with rates of nonfirearm violent death in the multivariable model. Fifth, although we found that states with more legislation have lower fatality rates, ie, are "safer" states, in a cross-sectional ecological study we could not determine if the greater number of laws were the reason for the reduced fatality rates. The association could have been confounded by firearm ownership rates or other unaccounted factors.

In conclusion, we found an association between the legislative strength of a state's firearm laws—as measured by a higher number of laws—and a lower rate of firearm fatalities. The association was significant for firearm fatalities overall and for firearm suicide and firearm homicide deaths, individually. As our study could not determine a cause-and-effect relationship, further studies are necessary to define the nature of this association.

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INVITED COMMENTARY

Responding to the Crisis of Firearm Violence in the United States

The United States has belatedly awakened to the knowledge that it is, in effect, under armed attack. More than 30 000 people are purposely shot to death each year—more than 300 000 since the World Trade Center was destroyed in 2001. Rates of firearm-related violent crime have increased 26% since 2008.[1] Physicians have joined others in demanding a strong response to this crisis. We look to scientific research to provide the evidence on which that response should be based. Such evidence should include a thorough exploration of risk and protective factors and, most importantly, controlled studies showing which interventions work to reduce firearm violence and why.

At a time when guidance is urgently needed, Fleegler and colleagues[2] have examined the relationship between firearm laws and firearm-related deaths in the United States. Their state-level ecological study (a design in which the unit of analysis is a population in aggregate, not the individuals in it) correlated the presence or absence of 28 laws arguably related to firearm violence with firearm-related mortality rates. Their main finding is that having more laws on the books is associated with having lower rates of firearm-related homicide and suicide. This would be an important finding—if it were robust and if its meaning were clear.

Ecological studies of association are inherently weak, however; correlation does not imply causation. This fundamental limitation is beyond the power of the authors to redress. And there are additional concerns. The study's