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Child Access Prevention Firearm Laws and Firearm Fatalities Among Children Aged 0 to 14 Years, 1991-2016

Hooman Alexander Azad, BS; Michael C. Monuteaux, ScD; Chris A. Rees, MD, MPH; Michael Siegel, MD, MPH; Rebekah Mannix, MD, MPH; Lois K. Lee, MD, MPH; Karen M. Sheehan, MD, MPH; Eric W. Fleegler, MD, MPH

➕ Editorial

➕ Supplemental content

IMPORTANCE Firearms caused more than 500 pediatric fatalities in 2017—a 50% increase from 2009. Laws regulating firearms are one approach to reducing pediatric firearm fatalities.

OBJECTIVE To evaluate the association between state child access prevention (CAP) firearm laws and pediatric firearm fatalities.

DESIGN, SETTING, AND PARTICIPANTS A state-level, cross-sectional study of CAP firearm laws throughout the United States, 1991-2016, was conducted using negative binomial regression to analyze differences in state fatality rates in children aged 0 to 14 years. Data analysis was performed from November 21, 2018, to October 18, 2019.

EXPOSURES Implementation of 2 categories of state CAP firearm laws: recklessness laws, which pertain to providing a firearm to a child, and negligence laws, which pertain to accessibility of a firearm within the home.

MAIN OUTCOMES AND MEASURES Rates of firearm fatalities across all intents and by specific intent (homicide, suicide, and unintentional) per 100 000 children aged 0 to 14 years.

RESULTS Twenty-five states passed CAP laws between 1989 and 2000. Between 1991 and 2016, 13 697 firearm fatalities occurred in children aged 0 to 14 years. Recklessness laws were not associated with changes in pediatric firearm fatality rates. Negligence laws overall were associated with significant reductions in firearm fatalities in children aged 0 to 14 years, with a 13% relative reduction in all firearm fatalities (95% CI, −18% to −7%), a 15% relative reduction in firearm homicides (95% CI, −22% to −7%), a 12% relative reduction in firearm suicides (95% CI, −20% to −2%), and a 13% relative reduction in unintentional firearm fatalities (95% CI, −24% to −1%). The most stringent negligence laws were associated with unintentional firearm fatality reductions of 59% (95% CI, −68% to −49%). A total of 3929 deaths (29% of all firearm deaths) were associated with states not having passed the most stringent form of negligence CAP laws.

CONCLUSIONS AND RELEVANCE In this study, negligence laws were associated with relative reductions in firearm fatality rates in children aged 0 to 14 years. The most stringent negligence laws were associated with the largest reductions in unintentional firearm fatalities. Recklessness laws were not associated with reduced firearm fatality rates. The passage of negligence CAP laws may have the potential to reduce firearm fatalities in children.

Author Affiliations: Feinberg School of Medicine, Northwestern University, Chicago, Illinois (Azad, Sheehan); Division of Emergency Medicine, Boston Children's Hospital, Boston, Massachusetts (Monuteaux, Rees, Mannix, Lee, Fleegler); Department of Pediatrics, Harvard Medical School, Boston, Massachusetts (Monuteaux, Rees, Mannix, Lee, Fleegler); Department of Community Health Sciences, Boston University School of Public Health, Boston, Massachusetts (Siegel); Department of Pediatrics, Lurie Children's Hospital, Chicago, Illinois (Sheehan).

Corresponding Author: Eric W. Fleegler, MD, MPH, Division of Emergency Medicine, Boston Children's Hospital, 300 Longwood Ave, Boston, MA 02115 (eric.fleegler@childrens.harvard.edu).

Pediatric firearm mortality in the United States is a public health problem, accounting for more than 500 deaths in children aged 0 to 14 years in 2017—a 50% fatality rate increase from 2009.[1] One-third of US households have at least 1 firearm (an estimated 22 million children exposed).[2] In 2015, 4.6 million US children lived in homes with at least 1 firearm stored in the most unsafe manner (ie, loaded with ammunition and unlocked).[3] In contrast, only 29% of firearm-owning households with children stored all their firearms unloaded and locked, as recommended by firearm safety advocates.[3-5]

Safe firearm storage limits firearm access to children. Many firearm fatalities in children, both unintentional and intentional, occur in the home. In one Texas study, 64% of firearm-related injuries in children presenting to the emergency department occurred in the home.[6] Among these, 40% involved an unsecured firearm, 58% had unknown storage status, and only 1.7% involved firearms that were properly secured. For pediatric firearm suicides, 75% of the children used firearms stored in their own, a relative's, or a friend's residence.[7] When pediatric firearm fatalities occur, firearms are often stored in the least safe manner (ie, loaded and unlocked).[8]

Laws have been associated with a reduction in firearm mortality,[9-13] and one approach to reducing pediatric firearm injuries and deaths is through targeted, child-focused firearm laws. Child access prevention (CAP) laws are state-level laws regulating the storage of firearms in households with minors. These laws hold the parent or guardian liable for actions a child takes or potentially could take with a firearm.[14] In 1989, Florida passed the first US CAP law, followed by 24 other states, with the last new law passed in 2000 (**Figure 1**). The specifics regarding firearm access, penalties (ie, misdemeanor vs felony), age cutoff (<14, <16, and <18 years), and stringency vary by state. Some states have laws holding firearm owners liable for directly providing firearms to a minor (ie, recklessness laws). Other states have more stringent laws holding the firearm owner liable for the unsafe storage of firearms, with variability in how storage is defined and what penalties are imposed (ie, negligence laws).[15] Prior research has suggested that CAP laws reduce firearm mortality among children.[16-19] Our objective was to evaluate the association between state CAP firearm laws and pediatric firearm fatalities.

Key Points

Question Are state-level laws requiring safe storage of firearms associated with firearm fatalities in children aged 0 to 14 years?

Findings In this state-level, cross-sectional study throughout the United States, negligence-specific child access prevention firearm laws were associated with a 13% reduction in all-intent firearm fatalities, a 15% reduction in firearm homicides, a 12% reduction in firearm suicides, and a 13% reduction in unintentional firearm fatalities among children aged 0 to 14 years. Absence of the most stringent negligence laws accounted for 29% of pediatric firearm fatalities.

Meaning The passage of specific, comprehensive firearm safe storage laws may reduce firearm fatalities in children.

Methods

Design

We conducted a state-level, cross-sectional, ecologic panel study to examine the association between state CAP laws and firearm fatalities in children aged 0 to 14 years from 1991 to 2016. Data analysis was conducted from November 21, 2018, to October 18, 2019. The exposure was presence of a state CAP law. The types of CAP law were evaluated separately, including recklessness laws and 3 types of negligence laws, categorized by degree of stringency. Recklessness laws hold a firearm owner liable if a child injures another person only if

Figure 1. Map of Type of Child Access Prevention (CAP) Laws by State and Year of Law Passage

NH: 2000
MA: 1998
RI: 1995
CT: 1990
NJ: 1992
DE: 1994
MD: 1991

☐ No CAP laws (n = 25)
☐ Recklessness laws (n = 9)
☐ Negligence–child uses (n = 9)
☐ Negligence–child accesses (n = 3)
☐ Negligence–child could access (n = 4)

[a] Nevada passed its current recklessness law in 1995 but had a negligence–child uses law in place from 1991 to 1995, when it was repealed and replaced with the current law.

[b] California passed its current negligence–child could access law in 2013 but had a negligence–child uses law in place from 1992 to 2012.

someone provided the firearm to the child. Of the 3 negligence law types, the narrowest are the child uses laws, which hold a firearm owner liable if a child accesses and uses an improperly stored firearm. The next type of negligence laws are the child accesses laws, which apply if a child accesses an improperly stored firearm, even if the child does not use the firearm. The final, most stringent type of negligence laws are the child could access laws, which apply if a child could potentially access an improperly stored firearm, regardless of whether they access it.[15] For analysis, we categorized the 5 types of CAP laws as (1) recklessness laws, (2) negligence-child uses laws, (3) negligence-child accesses laws, (4) negligence-child could access laws, and (5) any negligence laws (child uses, child accesses, or child could access). Because the study included only fatalities, it did not meet the definition of human subjects research and was deemed exempt from institutional review board approval by Boston Children's Hospital.

Data Sources

Firearm-related mortality among children aged 0 to 14 years was the primary outcome. These children were identified by *International Classification of Diseases, Ninth Revision* (*ICD-9*) and *International Statistical Classification of Diseases, Tenth Revision* (*ICD-10*) codes for firearm injuries from 2 publicly available data sets from the Centers for Disease Control and Prevention (eTable 1 in the Supplement). For fatalities from 1991 to 2007, we used the Web-Based Injury Statistics Query and Reporting System (WISQARS).[1] For fatalities from 2008 to 2016, we used the Centers for Disease Control and Prevention's Compressed Mortality File, as some state-level data in WISQARS were suppressed owing to low fatality counts.[20] Population data to calculate rates were obtained from the US Census.[21-23]

We stratified state-level, annual firearm fatality rates by intent, based on *ICD-9* and *ICD-10* classifications. Interactions between laws and age groups were assessed by stratifying the age of the child at death into 2 groups: 0 to 9 years and 10 to 14 years. We did not examine adolescents aged 15 to 19 years because (1) none of the CAP laws apply to youths aged 18 to 19 years; (2) after 2007, WISQARS suppressed data for cell sizes smaller than 10, which affected data available on single-year age groups; and (3) the Compressed Mortality File data are aggregated in 5-year age groups (ie, 10-14 and 15-19 years), and thus, data were not available only for youths aged 15 to 17 years for the study period.

Variables

Our main independent variable was the presence of a state CAP law, stratified by type and stringency. Data on that variable were compiled using the State Firearm Laws Database, which is an online resource of all firearm-related laws by state and year.[24-26] We also used the database to document the presence of 3 other state-level firearm laws previously associated with reduced firearm fatality rates[9,27-32]: (1) universal background check law: requires a background check to purchase handguns,[24] (2) handgun permit/license law: requires a license or permit to purchase handguns,[24] and (3) waiting period law: requires a minimum waiting period for the purchase of a handgun from a

dealer, without exemption for concealed carry or purchase permit holders.[24] We lagged state laws by 1 year to reflect the first full year that most laws were in effect. Thus, law data used in our analyses covered 1990-2015.

To measure state-level household firearm ownership rates, we used a validated proxy,[33] because no surveys assessed state-level household firearm ownership rates during the study period. This proxy is calculated using the proportion of suicides by firearms (firearm suicides/total suicides) and the state hunting license rate. Compared with other estimates, this proxy has been shown to correlate more closely with state-level gun ownership.[33]

Based on prior work, we also considered the following state-level covariates: alcohol consumption; population distribution by age, sex, and race/ethnicity; personal disposable income; rates of divorce, educational level, poverty, unemployment, and self-reported depression; household income level; population density; per capita gross domestic product; degree of urbanization; rates of violent crime, nonviolent crime, and incarceration; and law enforcement officers per capita (eTable 2 in the Supplement).[1,11,20,24,34-41]

Statistical Analysis

We modeled firearm-related mortality counts with state-year as the unit of analysis in a generalized, linear mixed-model framework using population sizes as an exposure, negative binomial models to account for overdispersion, robust SEs, and state-level random intercepts. We used a different stepping algorithm in nonconcave regions if the regression did not initially converge. First, we compared states with recklessness laws with states with no CAP laws. Next, we examined negligence laws against a combination of states with no CAP laws and states with recklessness laws. We analyzed states with each type of negligence law and then all states with any type of negligence law together. As a sensitivity analysis, we examined states with negligence laws against only states with no CAP laws. In addition, intent of death was analyzed in aggregate (all intents) and by specific intent (ie, homicide, suicide, and unintentional). As a validation measure, a separate analysis of mechanism of death (firearm vs nonfirearm) was conducted where indicated. We also calculated interaction effects between laws and age group (0-9 vs 10-14 years).

We calculated the population-attributable fraction (PAF), using a multilevel exposure with CAP laws of differing stringency.[42] We calculated the fraction of deaths attributable to states with no negligence laws and to those without the most stringent laws (negligence-child could access). We used negative binomial regression for year-specific data and for overall data (1991-2016).

We decided a priori to include the 3 other annual state-level firearm law variables, the annual firearm ownership rate proxy, and year (to account for secular trends) as covariates in all models. Among the remaining covariates, we retained in each model only those statistically significantly associated with the outcome. We used a backward selection process with a *P* value criterion of .10. The following covariates were retained in the main model: law enforcement officers per capita, population density, rates of incarceration, and rates of violent and

Figure 2. Rates of Firearm Fatalities per 100 000 Population

A | States with recklessness laws and states with negligence laws

B | States with no CAP laws
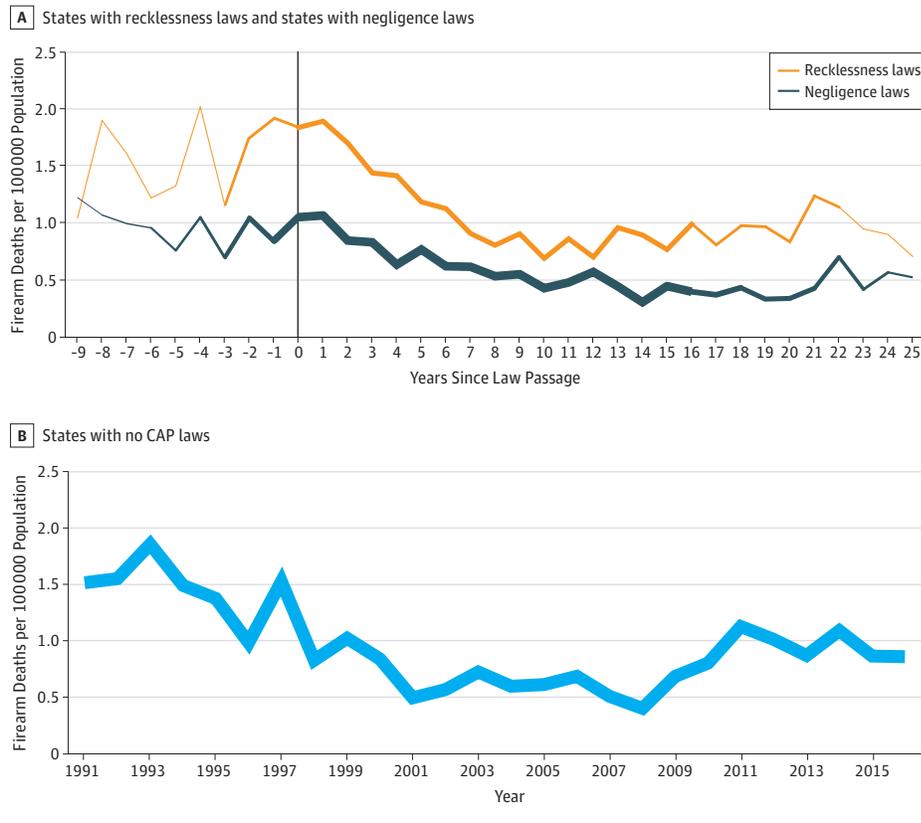
A, States with recklessness laws and states with negligence laws, averaged by years since law passage. The vertical line at 0 indicates the first year of law passage. The thinnest sections of the line for recklessness laws at years since law passage −9 to −4 indicate from 1 to 4 states and for negligence laws at years since law passage −9 indicates 2 states. The thinnest section of the line for recklessness laws at years since law passage 23 to 25 indicates from 1 to 2 states. B, States with no child access prevention (CAP) laws, averaged by calendar year. Line thickness is proportional to the number of states that contributed data in a particular year.

nonviolent crime. For the PAF, different covariates were retained, given that state-level effects could not be accounted for owing to lack of granularity of data: region-level effects, law enforcement officers per capita, percentage of the population that was black, alcohol consumption, and rates of incarceration and violent crime. The α level for significance was .05, and all tests were 2-tailed. Analyses were conducted using Stata, version 15.0 (StataCorp).

Results

During the 26-year study period, there were 13 697 firearm fatalities in children aged 0 to 14 years (annual incidence, 0.89 per 100 000 children). Of these, 56% were homicides, 22% were suicides, 19% were unintentional, and 3% were due to legal intervention or were of undetermined intent. The incidence of firearm fatalities decreased during the study period, from 1.5 per 100 000 in 1991 to 0.8 per 100 000 in 2016. Fatality rates varied across states over time, with a high of 7.1 per 100 000 children aged 0 to 14 years in Alaska in 2015 and a low of 0 firearm deaths in several states, for example, Connecticut and Delaware, across several years. Trends of firearm fatality rates in states with negligence laws, recklessness laws, and no CAP laws differed (**Figure 2**; eFigure in the Supplement).

In children aged 0 to 14 years, recklessness laws were not associated with firearm fatality rates in aggregate or by

specific intent (homicide, suicide, and unintentional). Negligence laws overall were associated with a 13% relative reduction in all firearm fatalities (95% CI, −18% to −7%), a 15% relative reduction in firearm homicides (95% CI, −22% to −7%), a 12% relative reduction in firearm suicides (95% CI, −20% to −2%), and a 13% relative reduction in unintentional firearm fatalities (95% CI, −24% to −1%). Incidence rate ratios are reported in the **Table**. In the sensitivity analyses comparing states with negligence laws with only states with no CAP laws, the effects were unchanged for firearm deaths in aggregate and firearm homicides. However, the negligence law effect was not statistically significant for firearm suicides (IRR, 0.92; 95% CI, 0.82-1.03) and unintentional firearm deaths (IRR, 0.91; 95% CI, 0.79-1.04).

Negligence-child uses laws were associated with a 9% relative reduction in all firearm deaths (IRR, 0.91; 95% CI, 0.84-0.99), but were not significantly associated with deaths when stratified by specific intent. Negligence-child accesses laws were associated with a 13% relative reduction in all-intent firearm deaths (IRR, 0.87; 95% CI, 0.78-0.98), an 18% relative reduction in firearm homicides (IRR, 0.82; 95% CI, 0.68-0.99), and a 16% relative reduction in firearm suicides (IRR, 0.84; 95% CI, 0.72-0.98). Negligence-child could access laws were associated with a 28% relative reduction in all-intent firearm deaths (IRR, 0.72; 95% CI, 0.52-0.99) and a 59% relative reduction in unintentional firearm deaths (IRR, 0.41; 95% CI, 0.32-0.51) (**Figure 3**; eTable 3 in the Supplement). The CAP law and age
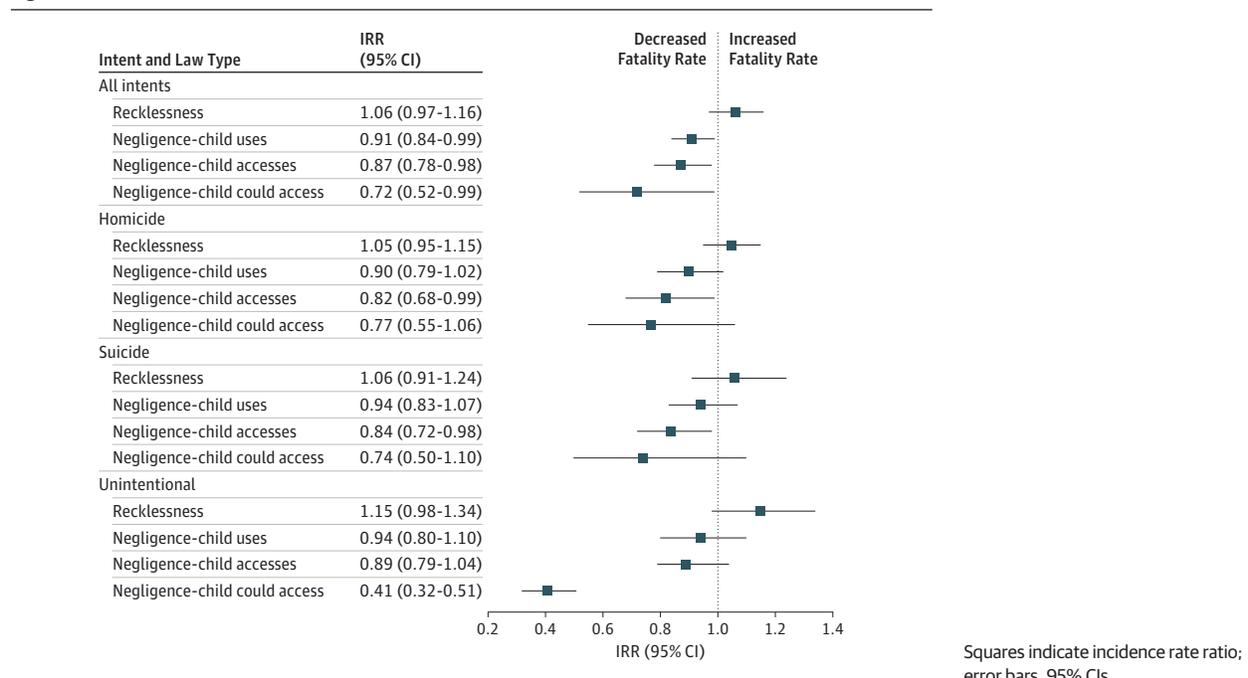
Table. IRRs by Intent and Age Group for Firearm Fatality Rates in Children Aged 0 to 14 Years, Any Recklessness Laws, and Any Negligence Laws

Intent	IRR (95% CI)
All intents	
States with recklessness laws	1.06 (0.97-1.16)
States with negligence laws	0.87 (0.82-0.93)[a]
Homicide	
States with recklessness laws	1.05 (0.95-1.15)
States with negligence laws	0.85 (0.78-0.93)[a]
Suicide	
States with recklessness laws	1.06 (0.91-1.24)
States with negligence laws	0.88 (0.80-0.98)[a]
Unintentional	
States with recklessness laws	1.15 (0.98-1.34)
States with negligence laws	0.87 (0.76-0.99)[a]

Abbreviation: IRR, incidence rate ratio.

[a] Statistically significant at α = .05.

Figure 3. Incidence Rate Ratios of Firearm Fatalities

Intent and Law Type	IRR (95% CI)
All intents	
Recklessness	1.06 (0.97-1.16)
Negligence-child uses	0.91 (0.84-0.99)
Negligence-child accesses	0.87 (0.78-0.98)
Negligence-child could access	0.72 (0.52-0.99)
Homicide	
Recklessness	1.05 (0.95-1.15)
Negligence-child uses	0.90 (0.79-1.02)
Negligence-child accesses	0.82 (0.68-0.99)
Negligence-child could access	0.77 (0.55-1.06)
Suicide	
Recklessness	1.06 (0.91-1.24)
Negligence-child uses	0.94 (0.83-1.07)
Negligence-child accesses	0.84 (0.72-0.98)
Negligence-child could access	0.74 (0.50-1.10)
Unintentional	
Recklessness	1.15 (0.98-1.34)
Negligence-child uses	0.94 (0.80-1.10)
Negligence-child accesses	0.89 (0.79-1.04)
Negligence-child could access	0.41 (0.32-0.51)

Squares indicate incidence rate ratio; error bars, 95% CIs.

group interaction terms were largely not statistically significant (eTable 4 in the Supplement).

Recklessness laws were not associated with nonfirearm fatality rates. Two specific negligence laws were associated with lower nonfirearm fatality rates: negligence-child uses laws for all intents (IRR, 0.95; 95% CI, 0.91-0.99) and negligence-child could access laws for all intents (IRR, 0.85; 95% CI, 0.77-0.94) and for unintentional deaths (IRR, 0.86; 95% CI, 0.78-0.94).

The PAF showed that 9% of all firearm deaths were associated with the absence of state-level negligence laws (95% CI, 4%-13%), equivalent to 1230 pediatric deaths (95% CI, 610-1836). Specifically, 9% of firearm homicides (95% CI, 2%-15%), 14% of firearm suicides (95% CI, 7%-21%), and 10% of unintentional firearm deaths (95% CI, 1%-18%) were associated with the absence of these laws (eTable 5 in the Supplement).

The PAF for the absence of negligence-child could access laws (the most stringent form of CAP law) was 29% of all firearm deaths (95% CI, 0.17-0.38), equivalent to 3929 deaths (95% CI, 2394-5267). By intent, 28% of firearm homicides (95% CI, 0.13-0.41) and 65% of unintentional firearm deaths (95% CI, 0.47-0.77) were associated with the absence of negligence-child could access laws. The PAF for firearm suicides attributable to the absence of the most stringent CAP law was not statistically significant (eTable 6 in the Supplement).

Discussion

In this study evaluating 26 years of firearm fatalities in US children aged 0 to 14 years, more-stringent CAP laws were associated with statistically significant relative reductions in pe-

diatric firearm fatalities. Negligence laws, but not recklessness laws, were associated with reductions in firearm fatalities. More-stringent negligence laws were associated with greater reductions in firearm fatalities. The most stringent CAP law—negligence-child could access—was associated with the greatest decrease in pediatric firearm-related deaths.

This study builds on prior CAP firearm law research[16-19,43,44] in 3 important ways. First, by including data over a wider period of postimplementation years (1991-2016), we have more power to detect differences in firearm fatality rates. Second, our analysis includes the presence of other key firearm laws and state-level factors, including firearm ownership rates, which could be confounders. Third, by also examining nonfirearm fatalities, we add a validity analysis to address the possibility that this relationship is associated with other statewide factors.

The magnitude of the association with state-level CAP laws ranged by type of negligence law, and for firearm suicides and unintentional firearm fatalities, is consistent with prior research.[16,17,45] Although the largest association was seen with negligence-child could access laws, all negligence law types (child uses, child accesses, and child could access) were associated with significant relative reductions in overall firearm deaths. Analysis of the laws' associations with separate age groups showed no significant interactions. However, we were limited by the available data in the granularity of age-specific effects that we could evaluate.

Reductions in homicide deaths with CAP laws have not been demonstrated in previous studies analyzing CAP laws and homicides.[16-19,43] This finding is important, as 56% of firearm-related deaths in children aged 0 to 14 years were due to homicide during the study period. However, data regarding the source of the firearm and the perpetrator in firearm homicides in this age group are not well known. A 2017 national survey found firearm homicides in younger children (aged 0-12 years) are often the result of intimate partner violence (31% of injuries), with the child being the target of unintentional cross fire. In older children (aged 13-17 years), the homicides are often related to an argument or are precipitated by another crime (71% of injuries) and are related to intimate-partner violence in 8% of the cases.[46]

One reason why CAP laws might be effective is that children frequently know the location of the household's firearm, despite parents believing the opposite. In one study, 73% of children younger than 10 years knew where their parent's firearm was stored, and 36% had handled the firearm, contradicting their parents' beliefs 39% and 22% of the time, respectively.[47] This finding is important to understand, as nearly 90% of unintentional pediatric firearm-related deaths occur in the home, and these deaths tend to occur when the children play with unsecured, loaded firearms in their parents' absence.[8] In children and youths aged 0 to 19 years, more than three-quarters of firearms used in suicide attempts and unintentional injuries were stored in the home.[7] Safe storage can reduce firearm deaths, with modest interventions that increase the number of locked firearms being projected to decrease firearm deaths among children by at least 10%.[48] As a result, it is crucial for health care professionals to address the safe storage of firearms in the home to reduce firearm mortality among children. Our study estimated that, if all states had passed the most stringent negligence CAP law, 3929 pediatric firearm deaths (29% of all pediatric firearm deaths) could have been prevented.

Limitations

These results should be considered in the context of their limitations. This was an ecologic study; thus, we cannot report causality between CAP laws and modification of individual behavior. The awareness of state residents of these laws in a particular state is unknown. We could not account for enforcement of these laws in our models. The general literature implies that there may be variability in prosecution of adults in cases of pediatric death by firearms on the state level, but these data are not publicly available.[49] In addition, the results could be accounted for by between-state differences, which could reflect intrinsic state-specific factors or other unmeasured confounders. Furthermore, there is the possibility of misclassification in the data, especially regarding the injury intent.[34] In addition, data on the perpetrators of homicides and unintentional fatalities in children are not readily available.

Conclusions

In this study, there was an association between more-stringent state CAP laws and decreased pediatric firearm fatality rates in children aged 0 to 14 years. Specifically, there was a significant reduction in firearm-related homicides, suicides, and unintentional firearm-related deaths in states with negligence CAP laws, but not in states with recklessness CAP laws. The passage of stringent negligence CAP laws across all states may have the potential to reduce firearm fatalities in children by up to 29%.

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