

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

*Culminating Experience: Northwestern University, Feinberg School of Medicine, School of Public Health*

Hooman Alexander Azad, BS<sup>1</sup>  
Michael C. Monuteaux, ScD<sup>2,3</sup>  
Chris A. Rees, MD, MPH<sup>2,3</sup>  
Michael Siegel, MD, MPH<sup>4</sup>  
Rebekah Mannix, MD, MPH<sup>2,3</sup>  
Lois K. Lee, MD, MPH<sup>2,3</sup>  
Karen M. Sheehan, MD, MPH<sup>1,5</sup>  
Eric W. Fleegler, MD, MPH<sup>2,3</sup>

**Presented At:** The Presidential Plenary of the American Association of Pediatrics, at the Pediatric Academic Societies Meeting on April 28, 2019

**Published In:** *JAMA Pediatrics*, online first\* on March 2, 2020

**Author Affiliations**

1. Feinberg School of Medicine, Northwestern University, Chicago, Illinois
2. Division of Emergency Medicine, Boston Children's Hospital, Boston, Massachusetts
3. Department of Pediatrics, Harvard Medical School, Boston, Massachusetts
4. Department of Community Health Sciences, Boston University School of Public Health, Boston, Massachusetts
5. Department of Pediatrics, Lurie Children's Hospital, Chicago, Illinois

**Disclaimers:** All views are those of the authors and are not an official position of the institutions listed or of any funder.

**Sources of Support:** None

**Word Count:** 4,128 words

**Number of Figures and Tables:** 5 Figures, 7 Tables

**Disclosure of Relationships and Activities:**

Azad: No conflicts were reported.

Monuteaux: No conflicts were reported.

Rees: No conflicts were reported.

Siegel: He reports having received funding from the Robert Wood Johnson Foundation to conduct and disseminate research on firearms.

Mannix: No conflicts were reported.

Lee: No conflicts were reported.

Sheehan: No conflicts were reported.

Fleegler: No conflicts were reported.

\* Azad HA, Monuteaux MC, Rees CA, Siegel M, Mannix R, Lee LK, et al. Child Access Prevention Firearm Laws and Firearm Fatalities among Children Aged 0 to 14 Years, 1991-2016. *JAMA Pediatr.* 2020;02115:1-7.

**Abstract:** (Methods and Results are quoted directly from the publication of this research completed by the author, Azad *et al.*, cited on the cover page)

**Public Health Relevance/Background:** Firearm violence in the United States is a pressing public health issue. In children, firearm violence is less-often discussed, and there has been less research surrounding pediatric firearm fatalities compared to those in adults. Yet, there was a 38% increase in pediatric firearm fatalities from 2009 to 2016. Using a Haddon Matrix helps determine ways to curb firearm violence, and attempts to change the environment surrounding firearm storage are the cornerstone of firearm laws called Child Access Prevention (CAP) laws. Some pertain to adults giving firearms to children (recklessness laws), while others pertain to the improper storage of firearms in the home (negligence laws). Prior research on CAP laws has been lacking, given a small number of years after implementation of the laws, and only early post-implementation data. Understanding the effect of CAP laws on pediatric firearm fatalities in the United States is critically important in addressing injury prevention in children.

**Methods:** This is a state-level, ecologic panel study using negative binomial regression to analyze differences in state pediatric firearm fatality rates performed on data from the United States on children ages 0-14 years between 1991 and 2016. The main exposure was implementation of two categories of state CAP laws: recklessness and negligence laws. Rates of firearm fatalities across all intents and by specific intent (homicide, suicide, unintentional) per 100,000 children ages 0-14 years was the primary outcome. A population-attributable fraction was calculated with respect to any negligence law and the most stringent form of negligence law.

**Results:** Twenty-five states passed CAP laws between 1989 and 2000. Over the 26-year period, there were 13,967 firearm fatalities in children ages 0-14 years old. Recklessness laws were not associated with changes in pediatric firearm fatality rates. Negligence laws were associated with significant reductions in firearm fatalities in children 0-14 years old. Negligence laws were associated with a 13% reduction in all firearm fatalities (95% CI -18%, -7%), a 15% reduction in firearm homicides (95% CI -22%, -7%), a 12% reduction in firearm suicides (95% CI -20%, -2%), and a 13% reduction in unintentional firearm fatalities (95% CI -24%, -1%). The most stringent negligence laws were associated with unintentional firearm fatality reductions of 59% (95% CI -68%, -49%). 3,929 deaths (29% of all firearm deaths) could be attributed to states not having passed the most stringent form of negligence CAP laws.

**Discussion:** Our study showed that recklessness laws were not associated with differences in firearm fatality rates, but that negligence laws were associated with lower overall rates of firearm fatalities, and lower rates of firearm homicides, suicides, and unintentional deaths. More stringent negligence laws were associated with larger reductions in fatality rate. Importantly, our study showed a reduction in pediatric firearm homicides with negligence CAP laws, the first study to show such a finding. Applying the Bradford-Hill criteria of causality to the existing evidence shows that the relationship between CAP laws and reduced pediatric firearm mortality has evidence for strength, biological gradient, specificity, consistency, and analogy, all of which argue in favor of a causal relationship. However, this is an observational study and we cannot determine causality from this form of study. A population-attributable fraction implied that up to 3,929 pediatric firearm fatalities could have been avoided with the passage of the strongest form of negligence law in all 50 states.

## **Introduction and Public Health Relevance**

Firearm violence in the United States is a topic of critical importance which has been receiving more attention from individuals trained in public health in recent years. It is a major source of death (1), a large number of which can be considered preventable. Public health approaches to curbing firearm violence abound, and understanding how firearm violence is perpetrated and the efficacy of various approaches is crucially important to being able to decrease the number of deaths caused by firearms in the United States.

Firearm violence among children is a topic which has received less attention, but which accounts for nearly 10% of deaths among children ages 14 years and younger in a given year (1). Trends over the past 25 years suggest that there has been some decline in the rates of pediatric firearm fatalities, from a rate of 1.47 firearm deaths per 100,000 children in 1991 to a rate of 0.80 firearm deaths per 100,000 children in 2016. However, the majority of this decrease occurred between 1991 and 2009, with a 38% increase in the rate of firearm fatalities between 2009 and 2016 (1).

Curbing pediatric firearm fatalities is of utmost public health importance, given that the vast majority of these can be considered preventable deaths. Multiple public health models can and should be applied in this context. A popular model used in the field of injury prevention is the Haddon Matrix, first developed in 1970 and since applied widely in understanding methods for injury prevention (2-4). The matrix allows individuals to analyze the various factors involved in an injury, including host, agent, and environmental factors at the time points prior to the event, during the event, and after the event.

For pediatric firearm fatalities, this offers many places for intervention (Figure 1). Prior to the event's occurrence, techniques such as firearm safety education, firearm and toy design,

and safe storage of firearms can help decrease the likelihood of a fatal or nonfatal injury. During the event itself, firearm safety education can make it less likely that a child will play with the firearm, firearm design including more safety features can make it less likely that the weapon will fire, and decreasing individual access to firearms can also curb fatalities. After the event, teaching parents what to do after a firearm injury, designing a system to notify a firearm owner if their firearm was discharged, and improved emergency medical services can decrease the likelihood that an injury will be fatal.

Changing agent characteristics has been explored but has been met with significant resistance. One method of changing a firearm so that it makes it less likely that a child might die from that firearm is by making it such that the firearm can only be discharged by the lawful owner, using proximity technology (5). New Jersey had adopted a law in 2002 that required the widespread adoption of “Safe Gun” technology once it became commercially available (6). Engage Armament, a firearm dealer in Maryland, attempted in 2014 to sell a Smart Gun, but was met with significant resistance from pro-firearm groups and decided against doing so (7) – there was concern that the sale of such a firearm would trigger the New Jersey law and require widespread adoption of “Safe Gun” technology. Groups such as the National Rifle Association opine that the passage of any firearm laws might lead the way to stricter firearm laws, citing a “slippery slope” argument (8). Therefore, changing agent characteristics has been attempted without significant success.

Educating children and families is important, but changing the environment in which children live is of critical importance. Many children are exposed to firearms daily, and ensuring that these children are safe when they are exposed to firearms is critical. Currently in the United States, more than 11 million homes in the United States have at least 1 firearm in the home (9).

Of these homes, somewhere between 29-39% stored firearms in the safest manner recommended by various pediatric health advocacy groups, which is both locked and unloaded (10-12). This means that over 50% of homes with at least one child and at least one firearm have their firearms stored in an unsafe manner. Of all children in the United States, 7% of them (4.6 million children) live in a home where a firearm is stored both loaded and not locked away, which is the least safe form of storage (10).

This is crucially important, because when children die as a result of firearm injury, these children die unsupervised (73.7% of cases) in their own homes (64% of cases) (13). The firearm tends to be stored in the home of the victim or someone close to the victim (75% of cases), and the firearms are much more likely to be stored in an unsafe manner (14-15). Clearly, one place for intervention is changing the environment in the home prior to the occurrence of an event, so as to decrease the likelihood of a pediatric firearm fatality.

Looking toward high-impact solutions to the problem of pediatric firearm violence, one can look to the Health Impact Pyramid for guidance (Figure 2) (16). This is a public health tool that helps estimate the population impact of an intervention versus the individual effort needed for that intervention. It postulates that by moving toward the base of the pyramid, you have significantly more population impact with less individual effort required, a combination that is very desirable in public health. Of the various interventions which can be placed on this pyramid, firearm laws which address storage of firearms, a pre-event intervention on the environment surrounding pediatric firearm fatalities, is a strong intervention which should have a large population impact.

Previous studies have looked at laws as a manner of making the environment surrounding firearms safer, and have shown significant associations between the passage of firearm laws and

fewer deaths from firearms (17-21). Having more firearm laws in a given state is associated with fewer firearm fatalities, with states with the most laws having 37% fewer firearm suicides and 40% fewer firearm homicides than states with the fewest laws (17). Looking at specific laws in adult populations, universal background check laws have been associated with a 14.9% reduction in overall homicides, and other laws were also associated with significant reductions in firearm homicides (18). At the county-level, these results hold true, and when considering proximity to other states, stronger firearm laws are associated with lower firearm suicide and homicide rates (19). In a large systematic review, Lee *et al.*, found that stronger firearm laws are associated with lower firearm homicide rates (20).

However, the bulk of this research was done in adult populations, and generalizability to pediatric populations is not immediately apparent. Various types of laws address pediatric firearm fatalities, and one specific type of law is the Child Access Prevention (CAP) law. These laws hold adults liable if they allow children to have access to firearms, and they vary significantly in strength (22-23). The first law was passed in Florida in 1989, and since then, 24 other states have passed CAP laws, with the last new state passing a law in the year 2000 (Figure 3). Laws vary by state (23). Some states hold adults responsible only if they give a firearm to a child (recklessness laws), whereas other laws apply to the storage of firearms (negligence laws) (23). Prior studies have looked at these laws, but the evidence base is not very strong (24-27). One of the most comprehensive studies on this topic was done in 1997 by Cummings, *et al.*, who found that CAP laws were associated with a 23% reduction in unintentional firearm deaths (24). Further studies looked at these laws again, and found significant reductions in unintentional firearm deaths in at least certain states, such as Florida and California (25). Studies have also described associated reductions in pediatric firearm suicides (26). Still, groups such as the

RAND Corporation describe that there are few studies that contribute to our understanding about pediatric firearm suicides and unintentional firearm deaths, and they state that we do not have any conclusive evidence of the effect of these laws on homicides and violent crime (22).

These studies were also completed at a time when these laws had not been in effect for very long, and the effects of legislation can take many years to become apparent. Prior studies have been limited by the number of post-implementation years that they could take into account, as the last new state to pass a CAP law did so in 2000. With a dataset through 2016, we are able to account for many more post-implementation years in many states, and better understand the true effect of CAP laws on pediatric firearm fatalities in the United States.

**Methods** (Methods are reproduced largely in Azad *et al.*, *JAMA Pediatr.* 2020, cited in full on title page)

### ***Design***

We conducted a state-level, ecologic panel study to examine the association between state CAP laws and firearm fatalities in children aged 0-14 years from 1991-2016. 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, groups by stringency. Recklessness laws are the least stringent form of law, and they hold firearm owners liable if an individual provides a firearm to a child, who then uses that firearm or injures another person. Negligence laws are more stringent, and they apply to the unsafe storage of firearms. The least stringent form of negligence law is the Negligence-Child Uses law, which holds an adult liable if a firearm is stored in an unsafe manner in the home, the child accesses the firearm, and the child uses that firearm. The next form of law is the Negligence-Child Accesses law, which is somewhat more stringent in that it does not require that the child use the firearm, only that the child access that

firearm. The most stringent form of law is the Negligence-Child Could Access law, which holds an adult liable if a child could potentially access an unsafely stored firearm, regardless of whether that child actually accesses the firearm (23). We examined recklessness and negligence laws separately, and then examined each type of negligence law independently, as well. 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.

### ***Data Sources***

Firearm-related mortality among children aged 0-14 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 datasets from the Centers for Disease Control and Prevention (Table 1). For fatalities from 1991-2007, we used the Web-based Injury Statistics Query and Reporting System (WISQARS) (1). For fatalities from 2008-2016, 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 (28). Population data to calculate rates were obtained from the US Census (29-31).

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: 0-9 years and 10-14 years old. We did not examine adolescents aged 15-19 years, because: (1) none of the CAP laws apply to youths aged 18-19 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 (i.e., 10-14 and 15-19 years), and thus, data were not available only for youths aged 15-17 years for the study period.

### *Variables*

Our main 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 (32-34). We also used the database to document the presence of 3 other state-level firearm laws previously associated with reduced firearm fatality rates (17, 35-40):

- Universal background check law: requires a background check to purchase handguns (32),
- Handgun permit/license law: requires a license or permit to purchase handguns (32), and
- 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 (32).

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 (41), because no surveys assessed state-level household firearm ownership rates during the study period. This proxy is calculated using the state hunting license rate and the proportion of suicides by firearm. Compared with other estimates, this proxy has been shown to correlate more closely with state-level gun ownership (41).

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 (Table 2) (1, 19, 28, 32, 42-49).

### *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 laws together. As a sensitivity analysis, we examined negligence laws against only states with no CAP laws. In addition, intent of death was analyzed in aggregate (all intents) and by specific intent (i.e., homicide, suicide, and unintentional). As a validation measure, a separate analysis of mechanism of death (firearm vs. non-firearm) 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 multi-level exposure with CAP laws of different stringency (50). We calculated the fraction of deaths attributable to states with no negligence laws and 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 related to 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 nonviolent crime. For the PAF, different covariates were retained, given that state-level effects could not be accounted for owing to the 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  $\alpha$  level for significance was .05, and all tests were 2-tailed. Analyses were conducted using Stata, version 15.0 (StataCorp).

**Results** (Results are reproduced largely in Azad *et al.*, *JAMA Pediatr.* 2020, cited in full on title page)

During the 26-year study period, there were 13,967 firearm fatalities in children aged 0-14 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 0-14 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 4).

In children aged 0-14 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 firearm fatalities across all intents (incidence rate ratio [IRR] 0.87; 95% CI, 0.82-0.93), a 15% relative reduction in firearm homicides (IRR, 0.85; 95% CI, 0.78-0.93), a 12% relative reduction in firearm suicides (IRR, 0.88; 95% CI, 0.80-0.98), and a 13% relative reduction in unintentional firearm fatalities (IRR, 0.87; 95% CI, 0.76-0.99) (Table 3). 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 death 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 5, Table 4). The CAP law and age group interaction terms were largely not statistically significant (Table 5).

In the way of a validity analysis, recklessness laws were not associated with non-firearm fatality rates. Two specific negligence laws were associated with lower non-firearm 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 1,230 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 (Table 6). 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 2,929 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 (Table 7).

## **Discussion**

Pediatric firearm mortality in the United States is a pressing public health issue, and this study found an association between the passage of CAP laws and reduced pediatric firearm mortality. In states with stronger CAP laws, fewer children died at the hands of a firearm, and the passage of these laws was associated with a lower firearm-specific mortality rate. Laws requiring the safe storage of firearms existed in only 25 states at the end of the study period, with no new states having passed a CAP law since 2000.

In our study, recklessness laws were not associated with reductions in firearm deaths. However, negligence laws were associated with significant reductions in pediatric firearm homicides, suicides, and unintentional deaths. The strongest form of negligence law – the negligence-child could access law – was associated with the largest reductions in pediatric firearm deaths. The effect existed for all types of deaths, but was strongest for unintentional pediatric firearm fatalities.

Our study also showed a significant reduction in pediatric firearm homicides, which prior studies have not done (24-25, 27). Further studies should look at the mechanisms whereby this effect might be plausible, as 56% of cases where children were killed by a firearm from 1991-2016 were classified as homicides. These laws were associated with a reduction in pediatric firearm homicides across the board, but more research is required to clarify and better understand this effect.

The reasons why these laws might be associated with reduced firearm fatalities are multiple. Many homes in the United States with children have firearms, and children know where these firearms are, despite parents believing the opposite. A study by Baxley and Miller (51) found that 73% of children under the age of 10 years knew where their parents' firearms were, despite only 34% of parents reporting that their children knew where their firearm was. More strikingly, 36% of these children had handled their parents' firearms; only 14% of parents were aware of this fact (51).

A population-attributable fraction was calculated for various types of negligence laws, and showed that up to 29% of pediatric firearm deaths were attributable to the absence of the strongest form of the negligence law – the negligence-child could access law. The passage of this

law in all 50 states could have prevented up to 3,929 pediatric firearm deaths during the study period.

Understanding the association between these laws and firearm fatalities is important, but understanding whether these laws have a causal relationship with reduced firearm fatality rates is critical. While this was an ecologic study and we cannot infer causality from this analysis, there are certain factors that argue in favor of causality in this case. The Bradford-Hill criteria are an oft-cited tool in epidemiology to argue in favor of a causal relationship, and they include: strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy (52). In the case of this study, we have evidence supporting strength, biological gradient, and specificity. Specifically, we have a dose-response relationship with the strongest form of law having a quite profound effect on unintentional firearm fatalities, with a 59% relative reduction in firearm fatality rates. In addition, our effect size represents a 12-15% reduction in pediatric firearm fatalities. Finally, our effect is specific to firearm fatalities, and we did not see a consistent, similar reduction in non-firearm fatalities. When appealing to prior research, we have evidence supporting consistency and analogy. Specifically, prior studies have found very similar reductions in unintentional deaths (24-25) and suicides (27). In addition, we have evidence for other firearm laws being associated with significant reductions in firearm fatalities among other age groups (17-21, 35-40). Therefore, while this study certainly cannot determine that CAP laws lead to fewer pediatric firearm fatalities, it adds to a body of evidence which appears to be in favor of a causal relationship.

This study must be considered in the context of its limitations. This is an observational study, and so all findings are associations and we cannot determine causality from this study. It is possible that other factors which were not controlled for in this study were responsible for the

reductions in pediatric firearm fatalities that were seen in this study. In addition, the CDC data on unintentional firearm deaths are possibly inaccurate, with around 40% of cases being classified as unintentional deaths inaccurately, or being classified instead as homicides or suicides, when the deaths were, in fact, unintentional (42). Finally, the study was only able to look at children ages 0-14 years, missing children ages 15-17 years as a result of data availability. It would be important to understand the effects of these laws on older children, as not all laws apply to children ages 15-17 years, and the causes of death in these older age groups vary from the younger age groups.

Further research is required to elucidate the relationship between these laws and pediatric firearm fatalities. In addition, further research should focus on specific factors in these deaths, including the source of the firearm, the circumstances surrounding these deaths, and the owner of the firearm. Finally, studies should look at the enforcement of various firearm laws at the state level, as it is important to consider the effect of a law in the context of its enforcement.

## **Conclusion**

Children die of firearm injury at an alarming rate in the United States, and specific firearm laws have been associated with reductions in these rates. Children who die at the hands of a firearm tend to do so within their own home, with a firearm which belongs to a parent or an individual close to the child. Many United States homes have firearms, and the majority are not stored in the safest manner. Children are able to and do access these firearms, often without parental supervision. The passage of focused, specific negligence-child could access laws in all 50 states could have prevented up to 3,929 pediatric firearm deaths from 1991 to 2016.

### References

1. Injury Prevention and Control: Data & Statistics (WISQARS) [Internet]. Washington, D.C.: Centers for Disease Control and Prevention; [cited 2019 Apr 20]. Available from <http://www.cdc.gov/injury/wisqars/index.html>.
2. Haddon W. On the escape of tigers: an ecologic note. *Am J Public Health Nations Health*. 1970;60(12):2229–34.
3. Haddon W. Options for the prevention of motor vehicle crash injury. *Isr J Med Sci*. 1980;16(1):45–65.
4. Runyan CW. Using the Haddon matrix: introducing the third dimension. *Inj Prev* [Internet]. 1998 Dec 1;4(4):302 LP – 307. Available from: <http://injuryprevention.bmj.com/content/4/4/302.abstract>
5. “Smart” Guns Backgrounder [Internet]. [Place unknown]; Violence Policy Center; 2013 [cited 2020 Mar 10]. Available from: [http://www.vpc.org/fact\\_sht/Smart\\_Gun\\_2013.pdf](http://www.vpc.org/fact_sht/Smart_Gun_2013.pdf).
6. An Act concerning the sale of handguns. P.L.2002, c.130 United States of America.
7. Rosenwald MS. Maryland dealer, under pressure from gun-rights activists, drops plan to sell smart gun [Internet]. Washington, D.C.; The Washington Post; 2014 May 2 [cited 2020 Mar 10]. Available from [https://www.washingtonpost.com/local/maryland-dealer-will-defy-gun-rights-advocates-by-selling-nations-first-smart-gun/2014/05/01/564efa48-d14d-11e3-937f-d3026234b51c\\_story.html](https://www.washingtonpost.com/local/maryland-dealer-will-defy-gun-rights-advocates-by-selling-nations-first-smart-gun/2014/05/01/564efa48-d14d-11e3-937f-d3026234b51c_story.html).
8. Sliding Down The Slippery Slope [Internet]. [Place unknown]; National Rifle Association - Institute for Legislative Action; 2007 [cited 2020 Mar 10]. Available from: <https://www.nraila.org/articles/20071219/sliding-down-the-slippery-slope>.
9. Schuster MA, Franke TM, Bastian AM, Sor S, Halfon N. Firearm storage patterns in US homes with children. *Am J Public Health* [Internet]. 2000 Apr;90(4):588–94. Available from: <http://ajph.aphapublications.org/doi/10.2105/AJPH.90.4.588>
10. Azrael D, Cohen J, Salhi C, Miller M. Firearm Storage in Gun-Owning Households with Children: Results of a 2015 National Survey. *J Urban Heal* [Internet]. 2018 Jun 10;95(3):295–304. Available from: <http://link.springer.com/10.1007/s11524-018-0261-7>
11. Resolution on firearm violence research and prevention [Internet]. [Place unknown]; APA Council of Representatives; 2014 [cited 2019 Oct 21]. Available from <https://www.apa.org/about/policy/firearms>.
12. State advocacy focus: Safe storage of firearms [Internet]. [Place unknown]; American Academy of Pediatrics; 2018 [cited 2019 Oct 21]. Available from <https://www.aap.org/en-us/advocacy-and-policy/state-advocacy/Documents/Safe%20Storage.pdf>.
13. Brewer JW, Cox CS, Fletcher SA, Shah MN, Sandberg M, Sandberg DI. Analysis of pediatric gunshot wounds in Houston, Texas: A social perspective. *J Pediatr Surg*. 2019 Apr;54(4):783–91.
14. Grossman DC, Mueller BA, Riedy C, Dowd MD, Villaveces A, Prodzinski J, et al. Gun storage practices and risk of youth suicide and unintentional firearm injuries. *J Am Med Assoc*. 2005;293(6):707–14.
15. Grossman DC, Reay DT, Baker SA. Self-inflicted and unintentional firearm injuries among children and adolescents: The source of the firearm. *Arch Pediatr Adolesc Med*. 1999;153(8):875–8.

16. Frieden TR. A framework for public health action: The health impact pyramid. *Am J Public Health*. 2010;100(4):590–5.
17. Fleegler EW, Lee LK, Monuteaux MC, Hemenway D, Mannix R. Firearm legislation and firearm-related fatalities in the United States. *JAMA Intern Med*. 2013;173(9):732–40.
18. Siegel M, Pahn M, Xuan Z, Fleegler E, Hemenway D. The Impact of State Firearm Laws on Homicide and Suicide Deaths in the USA, 1991–2016: a Panel Study. *J Gen Intern Med*. 2019;34(10):2021–8.
19. Diez C, Kurland RP, Rothman EF, Bair-Merritt M, Fleegler E, Xuan Z, et al. State intimate partner violence-related firearm laws and intimate partner homicide rates in the United States, 1991 to 2015. *Ann Intern Med*. 2017;167(8):536–43.
20. Lee LK, Fleegler EW, Farrell C, Avakame E, Srinivasan S, Hemenway D, et al. Firearm laws and firearm homicides: A systematic review. *JAMA Intern Med*. 2017;177(1):106–19.
21. Kaufman EJ, Morrison CN, Branas CC, Wiebe DJ. State firearm laws and interstate firearm deaths from homicide and suicide in the United States a cross-sectional analysis of data by county. *JAMA Intern Med*. 2018;178(5):692–700.
22. The effects of child-access prevention laws [Internet]. Santa Monica; RAND Corporation; 2019 [cited 2019 Mar 20]. Available at: <https://www.rand.org/research/gun-policy/analysis/child-access-prevention.html>.
23. Child access prevention [Internet]. San Francisco; Giffords Law Center to Prevent Gun Violence; 2018 [cited 2019 Mar 20]. Available at: <https://lawcenter.giffords.org/gun-laws/policy-areas/child-consumer-safety/child-access-prevention/>.
24. Cummings P, Grossman DC, Rivara FP, Koepsell TD. State gun safe storage laws and child mortality due to firearms. *J Am Med Assoc*. 1997;278(13):1084–6.
25. Hepburn L, Azrael D, Miller M, Hemenway D. The effect of child access prevention laws on unintentional child firearm fatalities, 1979-2000. *J Trauma - Inj Infect Crit Care*. 2006;61(2):423–8.
26. Gius M. The impact of minimum age and child access prevention laws on firearm-related youth suicides and unintentional deaths. *Soc Sci J*. 2015 Jun 1;52(2):168–75.
27. Webster DW, Vernick JS, Zeoli AM, Manganello JA. Association between youth-focused firearm laws and youth suicides. *J Am Med Assoc*. 2004;292(5):594–601.
28. National Center for Health Statistics. Compressed Mortality File, 1999-2016 (machine readable data file and documentation, CD-ROM Series 20, No. 2V) as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Hyattsville, Maryland. 2017.
29. State Population by Characteristics: 2010-2017 [Internet]. [Place unknown]; U.S. Census Bureau; 2017 [cited 2019 Mar 20]. Available at <https://www.census.gov/data/datasets/2017/demo/popest/state-detail.html>.
30. Intercensal Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2010 [Internet]. [Place unknown]; U.S. Census Bureau; 2010 [cited 2019 Mar 20]. Available at <https://www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-state.html>
31. U.S. Census Bureau (2000). State and County Intercensal Tables: 1990-2000 [Internet]. [Place unknown]; U.S. Census Bureau; 2000 [cited 2019 Mar 20]. Available at <https://www.census.gov/data/tables/time-series/demo/popest/intercensal-1990-2000-state-and-county-totals.html>

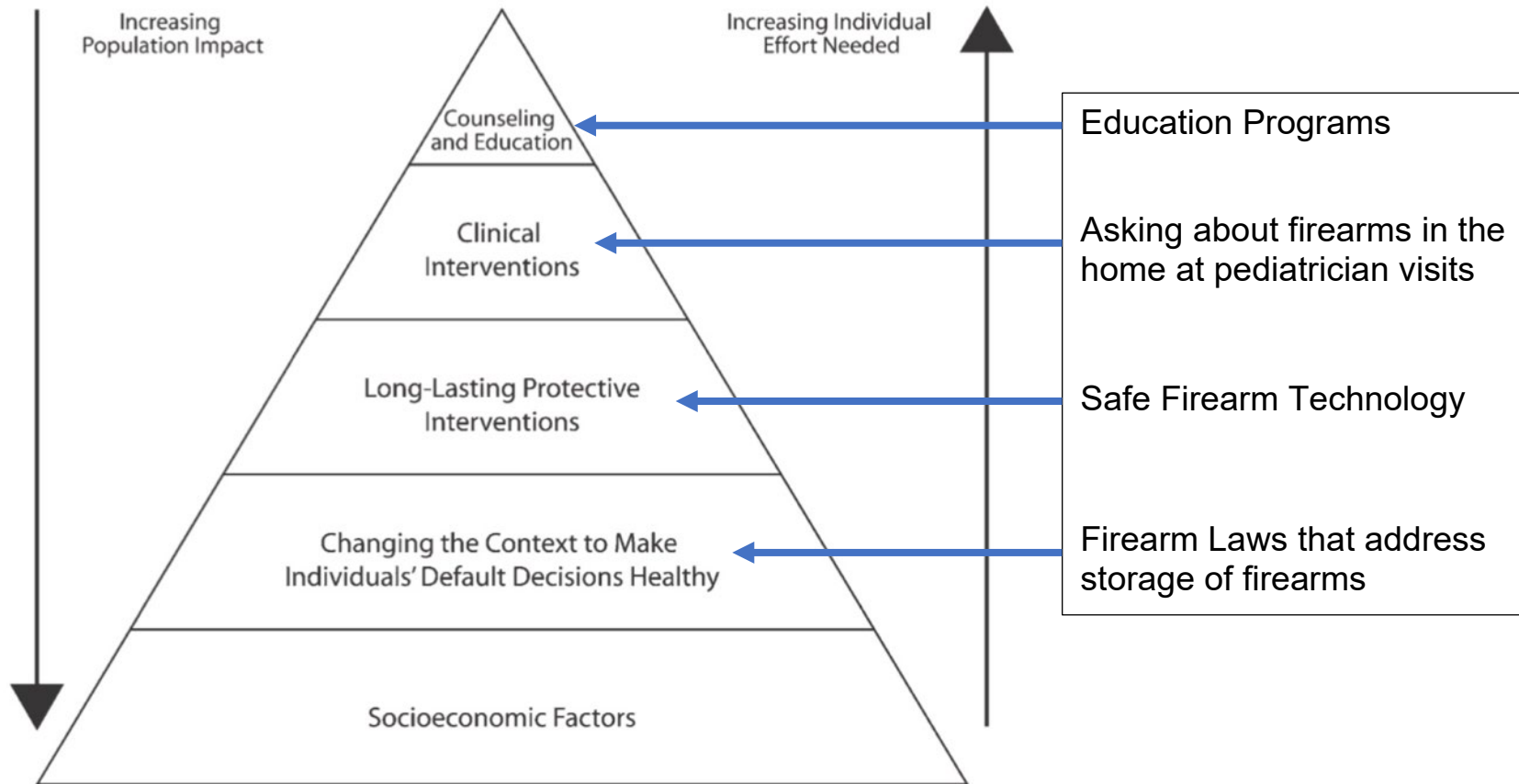
32. State Firearm Laws Database [Internet]. Boston; Boston University School of Public Health [cited 2018 Oct 17]. Available at <http://statefirearmlaws.org>.
33. Siegel M, Pahn M, Xuan Z, Ross CS, Galea S, Kalesan B, et al. Firearm-Related Laws in All 50 US States, 1991–2016. *Am J Public Health*. 2017 Jul;107(7):1122–9.
34. State firearm law database. New York; Everytown for Gun Safety; 2016 [cited 2018 Oct 17]. Available at <http://everytownresearch.org>.
35. Crifasi CK, Merrill-Francis M, McCourt A, Vernick JS, Wintemute GJ, Webster DW. Association between Firearm Laws and Homicide in Urban Counties. *J Urban Heal* [Internet]. 2018 Jun 21;95(3):383–90. Available from: <http://link.springer.com/10.1007/s11524-018-0273-3>
36. Rudolph KE, Stuart EA, Vernick JS, DW. W. Association between Connecticut’s permit-to-purchase handgun law and homicides. *Am J Public Heal*. 2015;105(8):49–54.
37. Webster D, Crifasi CK, Vernick JS. Effects of the Repeal of Missouri’s Handgun Purchaser Licensing Law on Homicides. *J Urban Heal* [Internet]. 2014 Apr 7;91(2):293–302. Available from: <http://link.springer.com/10.1007/s11524-014-9865-8>
38. Sumner SA, Layde PM, Guse CE. Firearm Death Rates and Association with Level of Firearm Purchase Background Check. *Am J Prev Med* [Internet]. 2008 Jul;35(1):1–6. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0749379708003103>
39. Ruddell R, Mays GL. State background checks and firearms homicides. *J Crim Justice* [Internet]. 2005 Mar;33(2):127–36. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0047235204001394>
40. Luca M, Malhotra D, Poliquin C. Handgun waiting periods reduce gun deaths. In: *Proc Natl Acad Sci. U. S. A*; 2017. p. 12162–5.
41. Siegel M, Ross CS, King C. Examining the relationship between the prevalence of guns and homicide rates in the USA using a new and improved state-level gun ownership proxy. *Inj Prev* [Internet]. 2014 Dec;20(6):424–6. Available from: <http://injuryprevention.bmj.com/lookup/doi/10.1136/injuryprev-2014-041187>
42. Barber C, Hemenway D. Too many or too few unintentional firearm deaths in official U.S. mortality data? *Accid Anal Prev* [Internet]. 2011 May;43(3):724–31. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0001457510002976>
43. LaVallee RA, Yi H. Apparent per capita alcohol consumption: National, State, and Regional Trends, 1977-2016. Atlanta; National Institute on Alcohol Abuse and Alcoholism; 2018 [cited 2019 Mar 20].
44. Population & Demographics. Atlanta; Southern Regional Education Board [cited 2019 Mar 20].
45. Divorce rates by state: 1990, 1995, and 1999-2017. [Place unknown]; Centers for Disease Control and Prevention [cited 2019 Mar 20]. Available at <https://www.cdc.gov/nchs/data/dvs/state-divorce-rates-90-95-99-17.pdf>.
46. Economic and Government Data: Employment and Unemployment in the Civilian Labor Force. Atlanta; Southern Regional Education Board [cited 2019 Mar 20].
47. Behavioral Risk Factor Surveillance System annual surveys, 1991-2016. [Place unknown]; Centers for Disease Control and Prevention [cited 2019 Mar 20].
48. Uniform Crime Reporting statistics. [Place unknown]; Federal Bureau of Investigation; 2017 [cited 2019 Mar 20].
49. National prisoner statistics. [Place unknown]; U.S. Department of Justice: Prisoner Series reports; 2017 [cited 2019 Mar 20].

50. Karb RA, Subramanian S V, Fleegler EW. County Poverty Concentration and Disparities in Unintentional Injury Deaths: A Fourteen-Year Analysis of 1.6 Million U.S. Fatalities. Schanzer DL, editor. PLoS One [Internet]. 2016 May 4;11(5):e0153516. Available from: <https://dx.plos.org/10.1371/journal.pone.0153516>
51. Baxley F, Miller M. Parental misperceptions about children and firearms. *Arch Pediatr Adolesc Med.* 2006;160(5):542–7.
52. Hill AB. The Environment and Disease: Association or Causation? In: *Proceedings of the Royal Society of Medicine.* 1965. p. 295–300.
53. Historical hunting license data. [Place unknown]; U.S. Fish & Wildlife Service; 2017 [cited 2019 Mar 20].

Figure 1. The Haddon Matrix (2-4) for pediatric firearm fatalities. This includes examples under each category, which are to act as representative actions which could be taken.

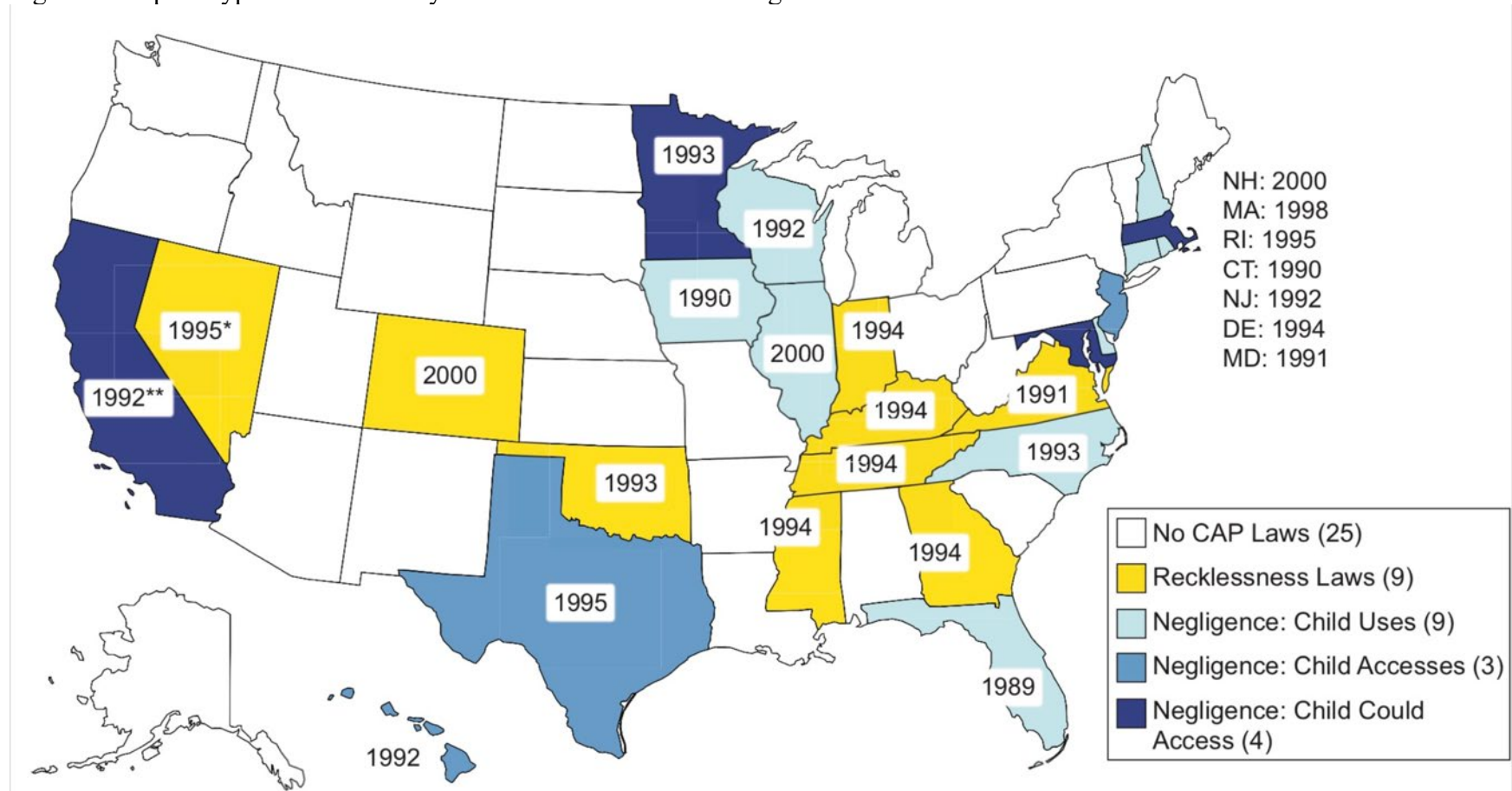
|                   | <b>Host</b>   | <b>Agent</b>  | <b>Environment</b>  |
|-------------------|---|---|---|
| <i>Pre-Event</i>  | <ol style="list-style-type: none"> <li>1. Firearm safety education</li> <li>2. Improved mental health services</li> <li>3. Physician counseling on gun safety at pediatric office visits</li> </ol> | <ol style="list-style-type: none"> <li>1. Stop making children’s toys that look like firearms</li> </ol>                                      | <ol style="list-style-type: none"> <li>1. Legislation preventing unsafe firearm storage</li> <li>2. Legislation imposing liability for use of an unsafely stored firearm</li> <li>4. Decreased prevalence of firearms in homes with children</li> <li>5. Firearm background checks</li> </ol> |
| <i>Event</i>      | <ol style="list-style-type: none"> <li>1. Increase access to emergency mental health services</li> <li>2. Teach children to tell parents if they are afraid</li> </ol>                              | <ol style="list-style-type: none"> <li>1. Re-design firearm so that it will not fire unless the individual who owns it is using it</li> </ol> | <ol style="list-style-type: none"> <li>1. Separate storage of firearm and ammunition</li> <li>2. Helpful first aid tools easily accessible in the home</li> <li>3. Decrease access to firearms</li> </ol>   |
| <i>Post-Event</i> | <ol style="list-style-type: none"> <li>1. Teach parents relevant first aid in the case of a firearm injury</li> <li>2. Teach children steps to take after a firearm injury</li> </ol>               | <ol style="list-style-type: none"> <li>1. Re-design firearm to notify firearm owner if firearm is discharged – a virtual “safety”</li> </ol>  | <ol style="list-style-type: none"> <li>1. Improve EMS systems to get children to the hospital faster</li> <li>2. Improve first responder training to deal with firearm injuries in the field</li> <li>3. Increase funding for research at causes of firearm deaths</li> </ol>                 |

Figure 2. The Health Impact Pyramid for pediatric firearm fatalities (16). This includes example actions which could be taken at each level of the Health Impact Pyramid.



**FIGURE 1—The health impact pyramid.**

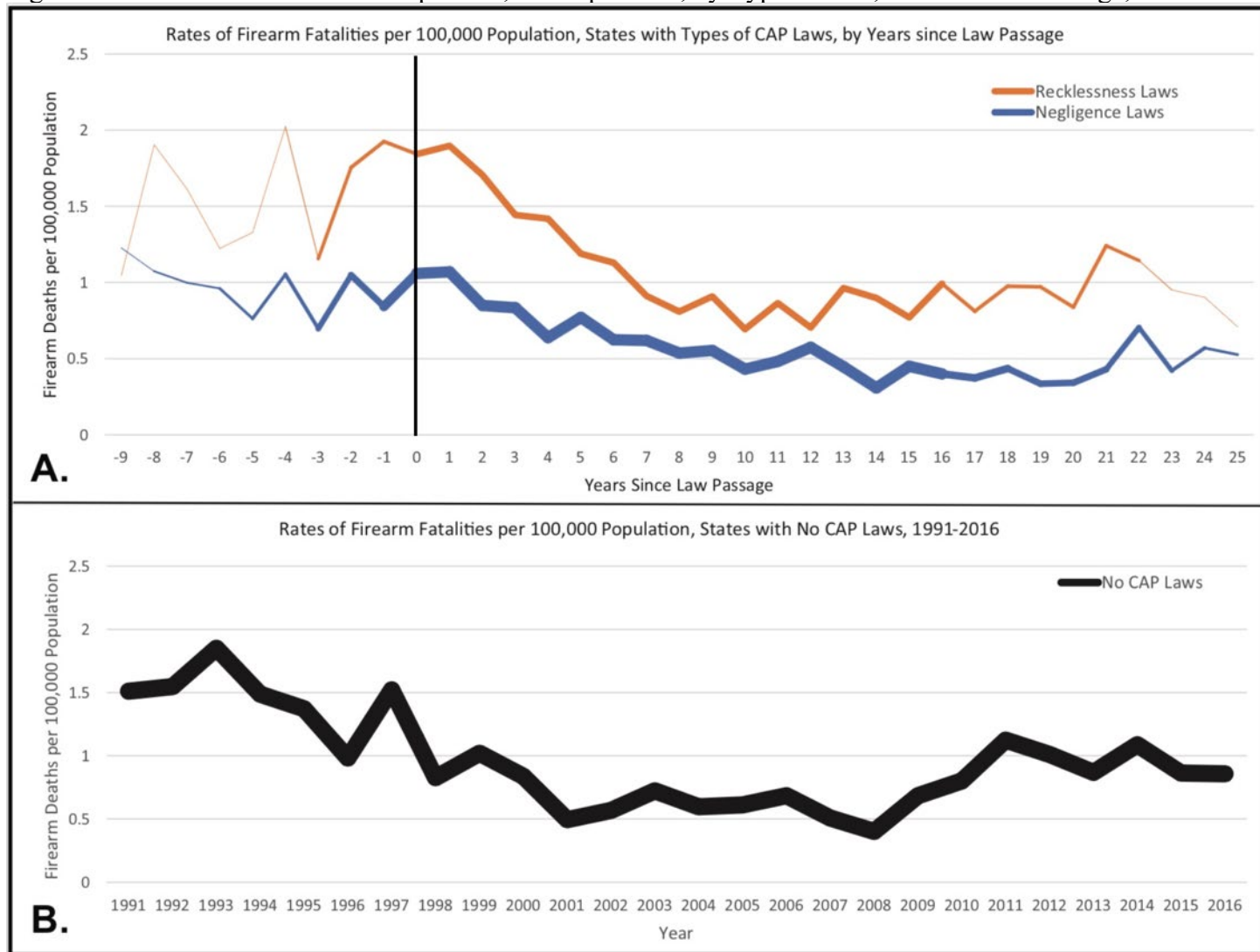
Figure 3. Map of Type of CAP Law by State and Year of Law Passage.



\* Nevada passed its current recklessness law in 1995, but had a negligence-child uses law in place from 1991-1995, when it was repealed and replaced with the current law.

\*\* California passed its current negligence-child could access law in 2013, but had a negligence-child uses law in place from 1992-2012.

Figure 4. Rates of Firearm Fatalities per 100,000 Population, by Type of Law, Year of Law Passage, in each state, 1991-2016.



A. States with recklessness laws and states with negligence laws, averaged by years since law passage. B. States with no CAP laws, averaged by calendar year.

Line thickness is proportional to the number of states that contributed data in a particular year.

Figure 5. Incidence Rate Ratios of Firearm Fatalities with 95% Confidence Intervals.

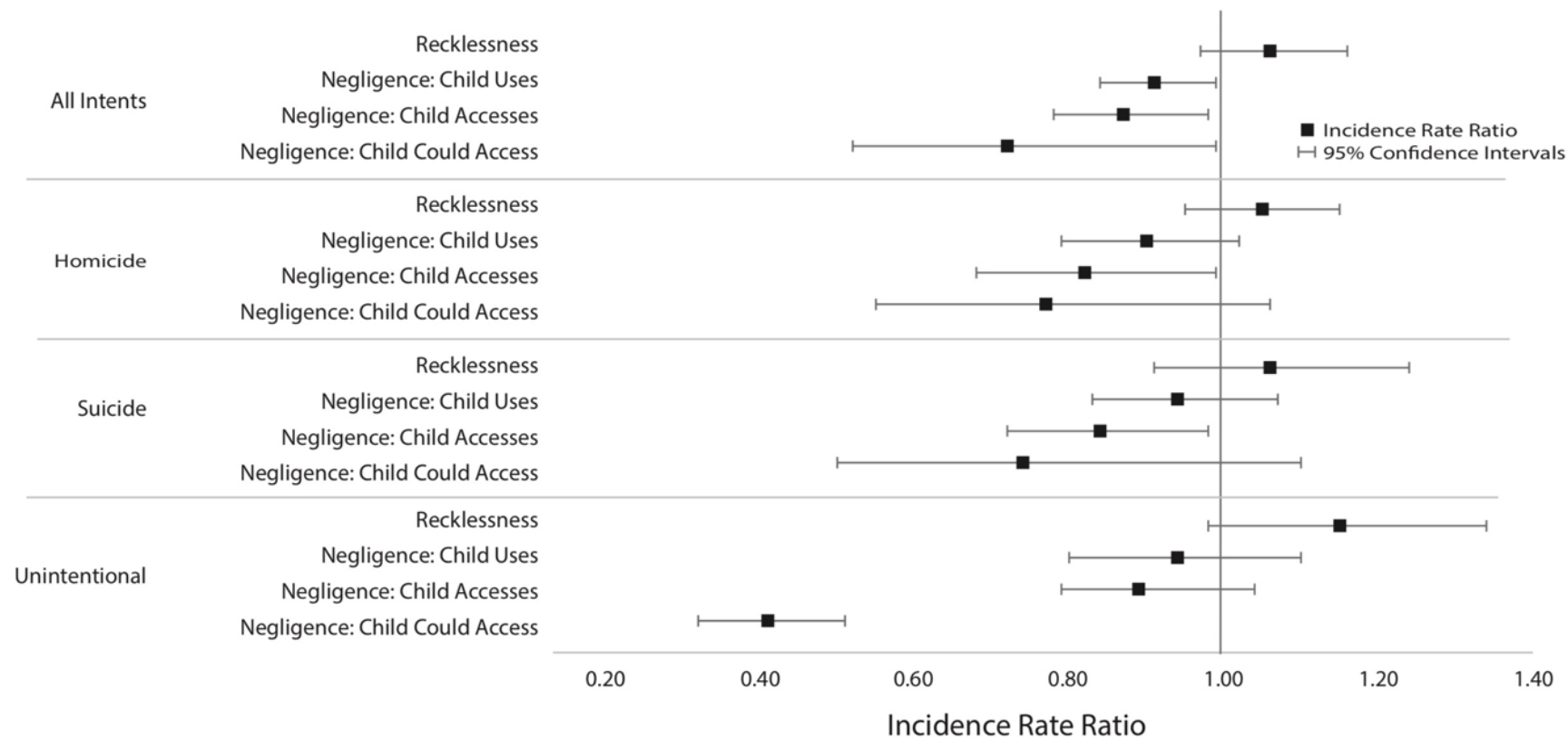


Table 1. ICD-9 and ICD-10 Codes by Intent and Mechanism

| <b>Group</b>                     | <b>ICD-9 Codes</b>                          | <b>ICD-10 Codes</b>                               |
|----------------------------------|---|---|
| <b>All Intents, All Injury</b>   | E800-E869, E880-E929, E950-E999             | V01-Y36, Y85-Y87, Y89, *U01-*U03                  |
| <b>All Intents, Firearm</b>      | E922, E955.0-.4, E965.0-.4, E985.0-.4, E970 | W32-W34, X72-X74, X93-X95, Y22-Y24, Y35.0, *U01.4 |
| <b>Homicides, All Injury</b>     | E960-E969                                   | X85-Y09, Y87.1, *U01-*U02                         |
| <b>Homicides, Firearm</b>        | E965.0-.4                                   | X93-X95, *U01.4                                   |
| <b>Suicides, All Injury</b>      | E950-959                                    | X60-X84, Y87.0, *U03                              |
| <b>Suicides, Firearm</b>         | E955.0-.4                                   | X72-X74   |
| <b>Unintentional, All Injury</b> | E800-E869, E880-E929                        | V01-X59, Y85-Y86                                  |
| <b>Unintentional, Firearm</b>    | E922  | W32-W34   |

Table 2. Variables and Data Sources (This table is largely quoted from Diez *et al.* (19) and specific variables, definitions for variables, and sources for variables are all quoted from that article. Table is provided not as original work but to provide specific references for covariates.)

| Variable                                       | Definition  | Source  | Missing Data |
|--|---|---|--------------|
| <b>Outcome Variables</b>                       |   |   |              |
| Child firearm fatality rates                   | Rate of firearm fatalities among 0- to 14-year-olds (total, homicide, suicide, and unintentional) per 100,000 persons   | 1991-2007: Web-based Injury Statistics Query and Reporting System (WISQARS) (1). 2008-2016: CDC's Compressed Mortality File (CMF) (28). | None         |
| <b>Main Predictor Variable</b>                 |   |   |              |
| State firearm laws                             | Recklessness laws (injury resulting from providing firearm to a child) and negligence laws related to unsafe storage of firearms with three levels (Negligence-Child Uses, Negligence-Child Accesses, and Negligence-Child Could Access)                                | State Firearm Laws Database (32)  | None         |
| <b>Control Variables</b>                       |   |   |              |
| Age  | Population aged 0-9 and 10-14 years   | WISQARS (1), CMF (28)   | None         |
| State firearm laws                             | Universal background check law; handgun permit/license law; waiting period law  | State Firearm Laws Database (32)  | None         |
| Household firearm ownership rate               | Proportion of households in which someone owns a firearm: Validated proxy derived from standard measure (firearm suicides divided by total suicides [FS/S] but adjusted for hunting license rate (HL); calculated as follows: proxy = (0.62 x FS/S) + 0.92 x HL - 4.478 | Calculations made for use as a control variable in prior work (19, 53)  | None         |
| Alcohol consumption                            | Per capita alcohol consumption among persons aged $\geq 14$ years   | National Institute on Alcohol Abuse and Alcoholism (43)   | None         |
| Population distribution by age                 | Percentage of population ages 15-29 years   | WISQARS (1)   | None         |
| Population distribution by sex                 | Percentage of population that is male   | WISQARS (1)   | None         |
| Population distribution by race: Black         | Percentage of the population that is black  | WISQARS (1)   | None         |
| Population distribution by ethnicity: Hispanic | Percentage of the population that is Hispanic   | U.S. Census Bureau. Current Population Surveys. Southern Regional Education Board: Population & Demographics (44)                       | None         |
| Per capita disposable income                   | Per capita disposable income (in 2010 U.S. dollars)   | Bureau of Economic Analysis. <i>Regional Data. GDP and Personal Income</i> . Washington, DC. U.S.                                       | None         |

| Variable                            | Definition  | Source  | Missing Data   |
|-------------------------------------|---|---|--|
| Divorce rate                        | Divorces per 1000 persons   | Department of Commerce, Bureau of Economic Analysis<br>CDC, National Center for Health Statistics. CDC and U.S. Bureau of the Census Statistical Abstracts (45) | Data interpolated in some years for California, Georgia, Hawaii, Indiana, Louisiana, and Minnesota |
| Unemployment rate                   | Percentage of unemployed persons among civilian labor force aged $\geq 16$ years                          | U.S. Bureau of Labor Statistics. Southern Regional Education Board: Economic and Government Data (46)   | None   |
| Poverty rate                        | Percentage of population living in poverty  | U.S. Census Bureau. Current Population Surveys. U.S. Census Bureau Historical Poverty Tables  | None   |
| Education                           | Percentage of adults aged $\geq 25$ years with college degree (bachelor's or higher)                      | U.S. Census Bureau. Current Population Surveys. U.S. Census Bureau Statistical Abstracts and Educational Attainment Reports.                                    | Data interpolated for 1992   |
| Self-reported depression rate       | Percentage of adults who report depression or other emotional problems during all of the previous 30 days | Behavioral Risk Factor Surveillance System Surveys (47)   | None   |
| Household income levels             | Median household income (in 2010 U.S. dollars)  | U.S. Census Bureau. Current Population Surveys. Southern Regional Education Board: Economic and Government Data (46)  | None   |
| Population density                  | Population per square mile  | U.S. Census Bureau  | None   |
| Per capita gross domestic product   | State gross domestic product divided by population  | Bureau of Economic Analysis. <i>Regional Data. GDP and Personal Income</i> . Washington, DC. U.S. Department of Commerce, Bureau of Economic Analysis           | None   |
| Degree of urbanization              | Percentage of population living in urbanized area or urban cluster  | U.S. Census Bureau. Decennial Censuses: 1990, 2000, 2010; U.S. Census Bureau Statistical Abstracts  | Data interpolated for 1991-1999 and 2001-2009  |
| Violent crime rate                  | Rates of aggravated assault, robbery and forcible rape per 100,000 persons                                | FBI Uniform Crime Reporting Statistics (48)   | None   |
| Nonviolent crime rate               | Rate of property crime (burglary, larceny-theft, and motor vehicle theft) per 100,000 persons             | FBI Uniform Crime Reporting Statistics (48)   | None   |
| Incarceration rate                  | Number of prisoners with sentences $>1$ year per 100,000 persons  | Department of Justice, Bureau of Justice Statistics, National Prisoner Statistics, Prisoner Series (49)   | Data interpolated for 1992   |
| Law enforcement officers per capita | Number of sworn police officers per 1000 persons  | FBI Uniform Crime Reports (48)  | None   |

Table 3. Incidence Rate Ratios and 95% Confidence Intervals by Intent and Age Group for Firearm Fatality Rates in Children 0-14 Years Old, Any Recklessness Laws and Any Negligence Laws.

| <b>Intent</b>                 | <b>IRR (95% CI)</b>              |
|-------------------------------|----------------------------------|
| All Intents                   |                                  |
| States with Recklessness Laws | 1.06 (0.97 to 1.16)              |
| States with Negligence Laws   | 0.87 (0.82 to 0.93) <sup>a</sup> |
| Homicide                      |                                  |
| States with Recklessness Laws | 1.05 (0.95 to 1.15)              |
| States with Negligence Laws   | 0.85 (0.78 to 0.93) <sup>a</sup> |
| Suicide                       |                                  |
| States with Recklessness Laws | 1.06 (0.91 to 1.24)              |
| States with Negligence Laws   | 0.88 (0.80 to 0.98) <sup>a</sup> |
| Unintentional                 |                                  |
| States with Recklessness Laws | 1.15 (0.98 to 1.34)              |
| States with Negligence Laws   | 0.87 (0.76 to 0.99) <sup>a</sup> |

<sup>a</sup> Statistically significant, alpha = 0.05.

Table 4. Incidence Rate Ratios and 95% Confidence Intervals by Intent and Age Group for Firearm Fatality Rates in Children 0-14 Years Old, Any Recklessness Laws, by Specific Negligence Laws

| <b>Intent</b>                                   | <b>IRR (95% CI)</b>              |
|---|----------------------------------|
| <b>All Intent</b>                               |                                  |
| States with Recklessness Laws                   | 1.06 (0.97 to 1.16)              |
| States with Negligence: Child Uses Laws         | 0.91 (0.84 to 0.99) <sup>a</sup> |
| States with Negligence: Child Accesses Laws     | 0.87 (0.78 to 0.98) <sup>a</sup> |
| States with Negligence: Child Could Access Laws | 0.72 (0.52 to 0.99) <sup>a</sup> |
| <b>Homicide</b>                                 |                                  |
| States with Recklessness Laws                   | 1.05 (0.95 to 1.15)              |
| States with Negligence: Child Uses Laws         | 0.90 (0.79 to 1.02)              |
| States with Negligence: Child Accesses Laws     | 0.82 (0.68 to 0.99) <sup>a</sup> |
| States with Negligence: Child Could Access Laws | 0.77 (0.55 to 1.06)              |
| <b>Suicide</b>                                  |                                  |
| States with Recklessness Laws                   | 1.06 (0.91 to 1.24)              |
| States with Negligence: Child Uses Laws         | 0.94 (0.83 to 1.07)              |
| States with Negligence: Child Accesses Laws     | 0.84 (0.72 to 0.98) <sup>a</sup> |
| States with Negligence: Child Could Access Laws | 0.74 (0.50 to 1.10)              |
| <b>Unintentional</b>                            |                                  |
| States with Recklessness Laws                   | 1.15 (0.98 to 1.34)              |
| States with Negligence: Child Uses Laws         | 0.94 (0.80 to 1.10)              |
| States with Negligence: Child Accesses Laws     | 0.89 (0.79 to 1.04)              |
| States with Negligence: Child Could Access Laws | 0.41 (0.32 to 0.51) <sup>a</sup> |

<sup>a</sup> Statistically significant, alpha = 0.05.

Table 5. Interaction Terms between Policy and Age Groups (0-9 Years v. 10-14 Years Old) for All-Intent Firearm Fatalities

| Intent  | Interaction Term IRR (95% CI)    |
|---|----------------------------------|
| <b>All Intents</b>                              |                                  |
| States with Recklessness Laws                   | 0.88 (0.77 to 1.00)              |
| States with Any Negligence Law                  | 0.90 (0.78 to 1.04)              |
| States with Negligence: Child Uses Laws         | 0.88 (0.73 to 1.05)              |
| States with Negligence: Child Accesses Laws     | 0.83 (0.74 to 0.94) <sup>a</sup> |
| States with Negligence: Child Could Access Laws | 1.21 (0.99 to 1.49)              |

<sup>a</sup> Statistically significant, alpha = 0.05.

Table 6. Population Attributable Fraction, Deaths Attributable to States with No Negligence Law

| Year                  | All Firearm Deaths |                                  |                                 | Firearm Homicides |                                  |                                | Firearm Suicides |                                  |                               | Unintentional Firearm Deaths |                                  |                              |
|-----------------------|--------------------|----------------------------------|---------------------------------|-------------------|----------------------------------|--------------------------------|------------------|----------------------------------|-------------------------------|------------------------------|----------------------------------|------------------------------|
|                       | Total Deaths       | PAF                              | Attributable Deaths             | Total Deaths      | PAF                              | Attributable Deaths            | Total Deaths     | PAF                              | Attributable Deaths           | Total Deaths                 | PAF                              | Attributable Deaths          |
| 1992                  | 892                | 0.32                             | 282                             | 479               | 0.54                             | 259                            | 175              | -0.27                            | -47                           | 216                          | 0.51                             | 109                          |
| 1993                  | 951                | 0.19                             | 178                             | 537               | -0.09                            | -51                            | 187              | 0.47                             | 87                            | 205                          | 0.44                             | 91                           |
| 1994                  | 867                | 0.19                             | 165                             | 461               | 0.15                             | 68                             | 188              | 0.15                             | 28                            | 185                          | 0.25                             | 46                           |
| 1995                  | 849                | 0.01                             | 11                              | 458               | 0.02                             | 11                             | 184              | -0.11                            | -20                           | 181                          | 0.27                             | 48                           |
| 1996                  | 690                | 0.07                             | 51                              | 376               | NA                               | NA                             | 162              | -0.11                            | -17                           | 138                          | NA                               | NA                           |
| 1997                  | 627                | 0.11                             | 71                              | 343               | 0.23                             | 80                             | 127              | 0.23                             | 29                            | 142                          | -0.27                            | -38                          |
| 1998                  | 611                | 0.14                             | 86                              | 313               | 0.24                             | 75                             | 154              | -0.09                            | -13                           | 121                          | 0.23                             | 28                           |
| 1999                  | 487                | -0.03                            | -15                             | 280               | 0.00                             | 1                              | 103              | -0.23                            | -24                           | 88                           | 0.37                             | 33                           |
| 2000                  | 435                | 0.10                             | 43                              | 226               | 0.34                             | 76                             | 110              | -0.11                            | -12                           | 86                           | NA                               | NA                           |
| 2001                  | 414                | 0.12                             | 50                              | 246               | 0.23                             | 58                             | 90               | -0.06                            | -5                            | 72                           | -0.09                            | -7                           |
| 2002                  | 417                | 0.14                             | 60                              | 261               | 0.01                             | 2                              | 86               | 0.45                             | 39                            | 60                           | 0.21                             | 13                           |
| 2003                  | 380                | 0.08                             | 30                              | 235               | -0.03                            | -7                             | 74               | 0.71                             | 52                            | 56                           | -0.63                            | -35                          |
| 2004                  | 355                | 0.17                             | 60                              | 223               | 0.29                             | 66                             | 59               | 0.21                             | 12                            | 63                           | 0.13                             | 8                            |
| 2005                  | 402                | 0.00                             | 1                               | 228               | NA                               | NA                             | 84               | 0.12                             | 10                            | 75                           | -0.63                            | -47                          |
| 2006                  | 406                | 0.10                             | 41                              | 283               | 0.20                             | 56                             | 62               | 0.47                             | 29                            | 53                           | -0.40                            | -21                          |
| 2007                  | 395                | 0.16                             | 62                              | 261               | 0.15                             | 38                             | 53               | 0.04                             | 2                             | 65                           | 0.27                             | 17                           |
| 2008                  | 376                | 0.05                             | 18                              | 252               | 0.06                             | 14                             | 50               | 0.02                             | 1                             | 62                           | 0.14                             | 9                            |
| 2009                  | 353                | 0.34                             | 121                             | 232               | 0.35                             | 81                             | 64               | 0.30                             | 19                            | 48                           | NA                               | NA                           |
| 2010                  | 379                | -0.12                            | -47                             | 218               | -0.07                            | -15                            | 81               | -0.31                            | -25                           | 62                           | -0.05                            | -3                           |
| 2011                  | 397                | -0.11                            | -43                             | 217               | 0.02                             | 4                              | 92               | -0.32                            | -30                           | 74                           | -0.25                            | -18                          |
| 2012                  | 411                | -0.10                            | -40                             | 241               | -0.21                            | -51                            | 105              | 0.41                             | 43                            | 58                           | 0.08                             | 5                            |
| 2013                  | 409                | 0.22                             | 89                              | 193               | 0.19                             | 36                             | 138              | 0.19                             | 27                            | 69                           | 0.33                             | 23                           |
| 2014                  | 457                | 0.24                             | 108                             | 223               | 0.10                             | 23                             | 174              | 0.50                             | 87                            | 49                           | 0.07                             | 4                            |
| 2015                  | 442                | 0.17                             | 73                              | 247               | 0.04                             | 9                              | 140              | 0.28                             | 40                            | 48                           | 0.16                             | 8                            |
| 2016                  | 488                | 0.11                             | 56                              | 236               | -0.11                            | -27                            | 160              | 0.47                             | 75                            | 74                           | 0.03                             | 2                            |
| <b>Total (95% CI)</b> | 13697              | 0.09 (0.04 to 0.13) <sup>a</sup> | 1230 (610 to 1836) <sup>a</sup> | 7684              | 0.09 (0.02 to 0.15) <sup>a</sup> | 677 (163 to 1180) <sup>a</sup> | 3058             | 0.14 (0.07 to 0.21) <sup>a</sup> | 434 (217 to 643) <sup>a</sup> | 2576                         | 0.10 (0.01 to 0.18) <sup>a</sup> | 248 (20 to 466) <sup>a</sup> |

<sup>a</sup> Statistically significant, alpha = 0.05.

Table 7. Population Attributable Fraction, Deaths Attributable to States without a Negligence-Child Could Access Law

| Year                  | All Firearm Deaths |                                  |                                  | Firearm Homicides |                                  |                                  | Firearm Suicides |                      |                     | Unintentional Firearm Deaths |                                  |                                  |
|-----------------------|--------------------|----------------------------------|----------------------------------|-------------------|----------------------------------|----------------------------------|------------------|----------------------|---------------------|------------------------------|----------------------------------|----------------------------------|
|                       | Total Deaths       | PAF                              | Attributable Deaths              | Total Deaths      | PAF                              | Attributable Deaths              | Total Deaths     | PAF                  | Attributable Deaths | Total Deaths                 | PAF                              | Attributable Deaths              |
| 1993                  | 951                | 0.41                             | 390                              | 537               | 0.09                             | 49                               | 187              | 0.65                 | 122                 | 205                          | NA                               | NA                               |
| 1994                  | 867                | 0.34                             | 295                              | 461               | 0.39                             | 179                              | 188              | 0.14                 | 26                  | 185                          | 0.56                             | 103                              |
| 1995                  | 849                | 0.32                             | 273                              | 458               | 0.37                             | 167                              | 184              | 0.26                 | 47                  | 181                          | 0.65                             | 118                              |
| 1996                  | 690                | 0.15                             | 105                              | 376               | 0.11                             | 42                               | 162              | -0.22                | -35                 | 138                          | 0.54                             | 75                               |
| 1997                  | 627                | 0.15                             | 91                               | 343               | -0.01                            | -3                               | 127              | 0.64                 | 81                  | 142                          | 0.51                             | 73                               |
| 1998                  | 611                | 0.25                             | 155                              | 313               | 0.20                             | 62                               | 154              | 0.14                 | 21                  | 121                          | 0.82                             | 100                              |
| 1999                  | 487                | 0.21                             | 103                              | 280               | 0.38                             | 107                              | 103              | -0.17                | -18                 | 88                           | 0.35                             | 31                               |
| 2000                  | 435                | 0.17                             | 73                               | 226               | 0.16                             | 36                               | 110              | 0.43                 | 47                  | 86                           | NA                               | NA                               |
| 2001                  | 414                | NA                               | NA                               | 246               | NA                               | NA                               | 90               | -0.03                | -2                  | 72                           | 1.00                             | 72                               |
| 2002                  | 417                | 0.08                             | 34                               | 261               | 0.11                             | 30                               | 86               | -0.16                | -13                 | 60                           | 1.00                             | 60                               |
| 2003                  | 380                | 0.01                             | 2                                | 235               | 0.11                             | 25                               | 74               | 0.48                 | 36                  | 56                           | -1.29                            | -72                              |
| 2004                  | 355                | 0.31                             | 110                              | 223               | 0.52                             | 117                              | 59               | -0.15                | -9                  | 63                           | 0.59                             | 37                               |
| 2005                  | 402                | 0.28                             | 112                              | 228               | 0.82                             | 186                              | 84               | -0.88                | -74                 | 75                           | -0.69                            | -51                              |
| 2006                  | 406                | -0.13                            | -52                              | 283               | 0.36                             | 101                              | 62               | -1.11                | -69                 | 53                           | 1.00                             | 53                               |
| 2007                  | 395                | 0.06                             | 22                               | 261               | 0.00                             | -1                               | 53               | -0.57                | -30                 | 65                           | NA                               | NA                               |
| 2008                  | 376                | 0.04                             | 15                               | 252               | -0.18                            | -45                              | 50               | NA                   | NA                  | 62                           | 1.00                             | 62                               |
| 2009                  | 353                | 0.53                             | 187                              | 232               | 0.57                             | 132                              | 64               | -0.59                | -38                 | 48                           | 1.00                             | 48                               |
| 2010                  | 379                | 0.17                             | 64                               | 218               | -0.02                            | -4                               | 81               | 0.20                 | 16                  | 62                           | 1.00                             | 62                               |
| 2011                  | 397                | -0.23                            | -93                              | 217               | -0.37                            | -81                              | 92               | -0.57                | -53                 | 74                           | 0.42                             | 31                               |
| 2012                  | 411                | 0.15                             | 60                               | 241               | -0.21                            | -51                              | 105              | 0.83                 | 87                  | 58                           | 0.43                             | 25                               |
| 2013                  | 409                | 0.46                             | 187                              | 193               | 0.71                             | 136                              | 138              | -0.23                | -32                 | 69                           | NA                               | NA                               |
| 2014                  | 457                | 0.71                             | 326                              | 223               | 0.67                             | 150                              | 174              | 0.75                 | 130                 | 49                           | 0.53                             | 26                               |
| 2015                  | 442                | 0.42                             | 184                              | 247               | 0.22                             | 55                               | 140              | 0.61                 | 85                  | 48                           | 1.00                             | 48                               |
| 2016                  | 488                | NA                               | NA                               | 236               | 0.50                             | 117                              | 160              | 0.45                 | 72                  | 74                           | 0.88                             | 65                               |
| <b>Total (95% CI)</b> | 13697              | 0.29 (0.17 to 0.38) <sup>a</sup> | 3929 (2394 to 5267) <sup>a</sup> | 7684              | 0.28 (0.13 to 0.41) <sup>a</sup> | 2159 (1009 to 3121) <sup>a</sup> | 3058             | 0.19 (-0.03 to 0.37) | 589 (-102 to 1135)  | 2576                         | 0.65 (0.47 to 0.77) <sup>a</sup> | 1665 (1206 to 1973) <sup>a</sup> |

<sup>a</sup> Statistically significant, alpha = 0.05.