

# The effect of state gun laws on youth suicide by firearm: 1981–2017

Jack Kappelman | Richard C. Fording PhD

Department of Political Science,  
University of Alabama, Tuscaloosa, AL,  
USA

## Correspondence

Jack Kappelman and Richard Fording,  
Department of Political Science,  
University of Alabama, 343 ten Hoor  
Bldg (UPS)/PO Box 870213 (USPS),  
Tuscaloosa, AL 35487, USA.  
Email: jakappelman@crimson.ua.edu;  
rcfording@ua.edu

## Abstract

**Background:** Many studies have found that state gun laws that regulate the purchase and possession of firearms can lead to a reduction in suicide rates. Yet, the literature has primarily focused on the effects of state gun laws on adult suicides, despite the fact that some gun laws are specifically tailored to restrict the purchase and possession of firearms by youths.

**Aims:** In this study, we estimate the effect of two such laws—Child Access Prevention (CAP) laws and minimum age laws—on youth suicide by firearm rates.

**Materials & Methods:** Our sample consists of state-level panel data for 41 states observed over the years 1981–2017.

**Results:** Based on a series of negative binomial regression analyses, we confirm previous research by finding that CAP laws are associated with a decrease in youth suicides by firearm, especially among males. However, we show that this effect is limited to states that have adopted relatively strict CAP laws. We also find that minimum age laws serve to reduce the youth suicide rate, but once again this effect is largely concentrated among males. Finally, we investigate the possibility that these effects were countered to some degree by “means substitution”—the substitution of firearms with other methods of suicide.

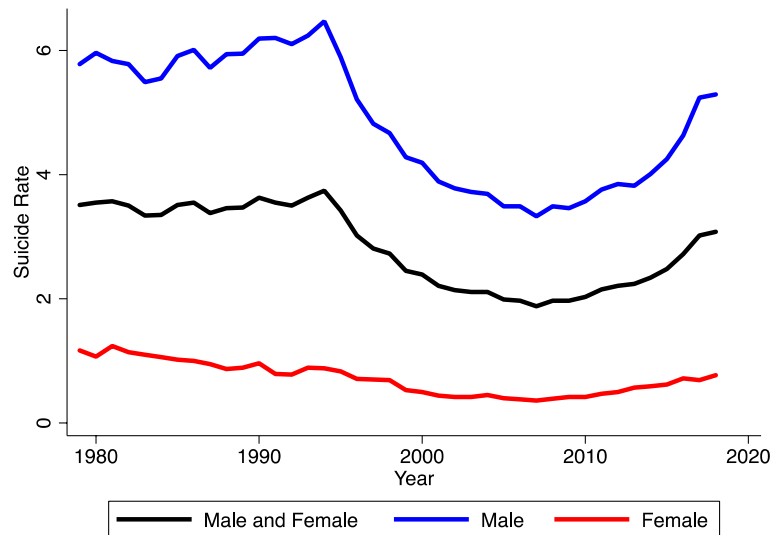
**Discussion:** Similar to other studies that have examined this question, we find no effect of youth-targeted gun laws on nonfirearm suicide deaths.

**Conclusion:** Despite the noteworthy increase in youth suicide rates over the last decade, our results suggest that state laws which restrict firearm access to young people continue to represent a potentially effective strategy for suicide reduction.

## INTRODUCTION

Suicide by firearm is one of the most pressing health crises in the United States today. With roughly half of all suicides being carried out by a firearm and suicides accounting for a third of all gun deaths in the United States, this issue has become a major focus of public health professionals (Pirelli et al., 2018). Contributing to this concern is the fact that while firearm suicide rates have increased across all age-groups, the increase has been particularly significant

among teens and young adults. This fact is evident in Figure 1, which presents annual data on firearm suicide rates for people aged 24 and under for the last four decades, 1979–2018. Since around 2006, the firearm suicide rate has steadily increased among all youth but it has been especially pronounced among males, who typically comprise 85%–90% of all suicide deaths by firearm. Indeed, between 2007 and 2018 the firearm suicide rate for male youths increased by approximately 60%. This value is nearly three times the rate of increase (23%) for the rest of the male



**FIGURE 1** Annual youth firearm suicide rate per 100,000 by gender, 1979–2018

Source: CDC WONDER (Underlying Cause of Death, 1979–2018) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

population (aged 25 and older; Centers for Disease Control and Prevention, 2020).

In response to these alarming trends, many states have adopted policies designed to limit youth access to firearms based on the assumption that this will lead to a reduction in the suicide rate. There is good reason to suspect that these laws have been effective. Research on firearm ownership among adults finds that while owning a firearm does not lead to an increase in suicidal thoughts, it does increase the chances that suicidal thoughts will be acted upon (Betz et al., 2011; Miller et al., 2013). As a suicide method, firearms are also especially lethal. Studies have found that although a firearm is used in fewer than 5% of all suicide attempts, firearms account for approximately 50% of all suicide fatalities (Anestis et al., 2017). Yet, even as more and more states have adopted policies that impose higher thresholds for purchase and possession of firearms, the rate of youth suicides by firearm has increased in recent years. Given this fact, it seems especially important to evaluate the effects of current efforts to prevent youth firearm suicides. Have states' efforts to limit youth access to firearms been effective in reducing suicide? In this paper, we seek to shed additional light on this question by examining the effects of two types of policies designed to limit youth access to firearms—Child Access Prevention (CAP) laws and minimum age laws—on the rate of youth suicide by firearm.

Our research seeks to identify the effect of gun laws on suicide rates in several important ways. First, most studies are quite dated and as a result are restricted to an examination of state laws adopted prior to 2000 (Cummings et al., 1997; Lott & Whitley, 2001; Rosengart et al., 2005; Webster et al., 2004). Some studies have examined a longer period of data but have focused on a small sample of states (DeSimone et al., 2013). The most comprehensive study, and the only

50-state study to examine data beyond 2001, is Gius (2015). Yet, because the analysis period ends at 2010, this study can say very little regarding the recent increase in youth suicide rates that began around 2007 and which has continued through 2018 (see Figure 1). In contrast, our study relies on a broad sample of 41 states for which youth suicide data are consistently available for the 37-year period, 1981–2017.

Second, while most studies have restricted their evaluation of the effect the CAP laws and minimum age laws to firearm suicides, we examine the effects of state gun laws on both firearm and nonfirearm suicides. Utilizing nonfirearm suicides as an additional dependent variable is valuable due to the fact that it provides the basis for a placebo test of the effects of gun laws, as there is no reason to expect that higher threshold gun laws should lead to a decrease in nonfirearm youth suicides. However, an examination of nonfirearm suicides is also critical to understanding the effects of gun laws on suicide because it is possible that the suicide-reducing effects of CAP laws and minimum age laws could be partly offset through means substitution—increases in suicides by other methods. Although some of the early studies of youth-targeted gun laws analyzed their impact on nonfirearm suicides (e.g., Webster et al., 2004), our study provides the first test of the effects of CAP laws and minimum age laws on both firearm and nonfirearm youth suicide rates utilizing data beyond 2000.

Finally, our indicators of state gun policy are more detailed than those used in past studies and thus lead to more nuanced conclusions regarding the effects of state firearm policies. We estimate the effects of two types of minimum age laws—minimum possession laws and minimum purchase laws.

In addition, in contrast to previous studies which rely on dichotomous indicators of state CAP laws, we employ an ordinal measure of CAP law stringency to estimate the effects of both weak and strong CAP laws. Although some studies

have similarly utilized a more sophisticated measure of CAP law stringency in their analyses, these studies provide no evidence that CAP law stringency matters (Cummings et al., 1997; Webster et al., 2004).

## GUN LAWS AND YOUTH SUICIDE BY FIREARM: THE EVIDENCE

Although there is a large literature on the effects of gun laws on various measures of violent crime, far fewer studies have examined the effects of gun laws on suicide and even fewer focus on youth suicide rates (Smart et al., 2020). The literature on youth suicide by firearm has largely focused on two types of gun laws, both of which are designed to limit youth access to guns. First, CAP laws refer to a range of laws which allow criminal charges to be brought by authorities against individuals who intentionally or carelessly allow children to have unsupervised access to a gun. According to research on youth firearm suicides, in more than 80% of cases, the decedent obtained the gun from a family member (Smart et al., 2020; Webster et al., 2002), and in the majority of such cases the gun was not securely stored (Conwell et al., 2002; Grossman et al., 2005). As a result, many states have designed CAP laws to also require that gun owners store their guns in a highly secure fashion in their home so that they cannot be easily accessed by children.

Not all CAP laws are the same. Some states, such as California, have implemented relatively strict laws by defining a minor as any child under 18 and subjecting those who violate the law to both civil and criminal liability, regardless of whether that access was provided intentionally or simply due to negligence. States with relatively weaker laws deviate from these provisions in some way, often by imposing a lower age threshold to define a minor or by limiting the definition of negligence and the potential penalties for granting “access” to a firearm. Nevertheless, most studies of CAP laws have disregarded this important distinction and have measured CAP laws in a dichotomous fashion—as either present or absent.

To date, five studies have estimated the effect of state CAP laws on youth firearm suicide rates using longitudinal, difference-in-difference methods that provide the best evidence of causal effects.<sup>1</sup> The findings from these studies are

<sup>1</sup>By “difference-in-difference” studies, we refer to quasi-experimental research designs which estimate the effect of gun policies by comparing the pre–post change in suicide rates among states that have adopted a gun policy (the treatment group) to the pre–post change in suicide rates in comparable states that have not adopted that gun policy (the control group). Studies of the effects of gun laws that rely on cross-sectional designs or simple longitudinal designs (without a control group) would therefore not be classified as difference-in-difference designs. In their comprehensive review of the literature on the effects of gun policy, Smart et al. (2020) rely on this criterion to identify the studies summarized in their review as they believe that such designs provide the strongest evidence of causal effects.

decidedly mixed. Two early studies examined the effects of CAP laws and safe storage laws using state panel data through the mid-1990s (Cummings et al., 1997; Lott & Whitley, 2001). Although the point estimates from these studies were negative and therefore consistent with mortality-reducing effects, the effects were not statistically significant. Webster et al. (2004) utilized state panel data from 1976 to 2001 to estimate the effects of laws regulating the possession, purchase, and storage of guns (including CAP laws) on youth suicide rates. They found that CAP laws were associated with an 8.3% reduction in firearm suicide rates among youths aged 14–17. The most comprehensive study of the effects of CAP laws on youth suicide by firearm is provided by Gius (2015). Based on state panel data for the years 1981–2010, Gius (2015) found that CAP laws had a statistically significant and negative effect on youth firearm suicide rates, with the magnitude of the effect similar to the estimates reported by Webster et al. (2004). Finally, DeSimone et al. (2013) evaluated the effect of CAP laws on nonfatal injuries in youths, many of which were due to nonfatal suicide attempts. Using data on hospital discharges for 11 states (7 of which had passed CAP laws between 1988 and 2003), they found CAP laws led to a statistically significant reduction in nonfatal, self-inflicted firearm injuries among youth under the age of 18. Although they did not examine gun deaths directly, one would presume that if they had they would have reached a similar conclusion due to the lethality of guns as a suicide method.

Minimum age laws are the second type of gun law that has been investigated, and there are only three studies of their effects on youth suicide by firearm using longitudinal, difference-in-difference methods. Although federal law establishes a minimum age of 18 years for the purchase and possession of firearms, many states have adopted laws that are stricter than the federal law (Rosengart et al., 2005). To date, it is unclear whether these laws have led to a significant reduction in youth access to firearms. Although young people often purchase guns through retail stores when allowed to do so, surveys of male high school students have found that a large percentage of youth report that they could easily obtain access to a variety of guns, including handguns, through other sources such as their home (Sheley & Wright, 1998; Ruback et al., 2011). Thus, the effectiveness of laws regulating the ability of youths to purchase firearms may be inherently limited due to easy availability from other sources. Laws regulating possession are not dependent on the source of the firearm and therefore may have greater potential to reduce firearm access, but only to the extent that youths anticipate significant costs of being caught possessing a firearm. To date, empirical studies that have examined the effects of minimum age laws have consistently found their adoption to have no effect on youth suicide rates (Gius, 2015; Rosengart et al., 2005; Webster et al., 2004).

## DATA AND MEASUREMENT

Data on youth suicide were downloaded from the CDC's online data portal (WONDER), which provides access to state-level data on deaths (by underlying cause) collected by the National Center for Health Statistics. We utilize data on the number of suicide deaths by firearm and nonfirearm methods for the 37-year period 1981–2017. One limitation of these data is that deaths are reported for 5-year age-groups. Therefore, we had to choose between the age-range 15–19 and 20–24 to define the oldest cohort of “youths” in our sample. Ultimately, we chose the 20–24 age interval, despite the fact that the oldest individuals included in our sample are over the age of 21 and may not be considered “youths” by most definitions. We did this for two reasons. First, nearly all of the minimum age laws that exceed federal law set the minimum age at 21. This means that 20-year-olds will be affected by these laws. Second, because many young adults continue to live with their parents, or have access to their parent's home, they could be impacted by CAP laws, especially if younger children also live in the household.

Another data constraint that we face concerns the fact that the CDC does not report state-level mortality data for state-years in which the total number of deaths is fewer than 10. For suicide by firearm data, this absence in reporting resulted in a total of 156 missing state-year observations spread across 12 different states throughout our period of analysis. The states for which data are missing are among the smallest states, as one would expect.<sup>2</sup> To preserve balance within our panel dataset, we excluded from our estimation sample those states that met one of the following two conditions: (a) The state had more than 10 missing observations across the entire 37-year analysis period, or (b) the state was missing data for two or more consecutive years. For states with missing observations that did not meet one of these criteria, we estimated the missing values using linear interpolation. Applying this strategy necessitated applying linear interpolation to estimate eight missing values for three states (Nebraska, South Dakota, and Wyoming). Our final estimation sample thus consists of a balanced panel of 41 states for the common period 1981–2017.

### Child access prevention laws

Child access prevention laws are designed to impose liability and accountability on gun owners for failing to prevent

minors from having access to firearms. As of 2017, 28 states had some form of a CAP law in place, with the vast majority of state adoptions occurring between 1990 and the early 2000s. However, not all CAP laws are structured the same way. Based on data on the content of CAP laws collected by Morral, Schell, and Smucker (2018), we coded CAP laws according to the presence or absence of four features of the law:

1. The law is limited to “intentional, reckless, or knowing provision” of a firearm to a minor.
2. The law goes beyond the first standard to cover “negligent” storage of a firearm.
3. The law defines a minor as less than the age of 18.
4. The law incurs civil liability upon the gun owner if a minor uses their firearm.

To measure CAP law stringency, we created an ordinal variable, where:

0 = no CAP law (22 states)

1 = weak CAP laws = no more than two of the policy features listed above (22 states)

2 = strong CAP laws = at least three of the policy features listed above (six states)

Our expectation is that strong CAP laws will have the largest negative effect on youth suicide by firearm, while weak CAP laws will have a smaller effect.

### Minimum age laws

We estimate the effect of minimum age laws by measuring state laws that regulate the minimum age to purchase and possess a handgun. We focus on handgun laws due to the fact that handguns are far more likely to be used for suicide than long guns (Lewiecki & Miller, 2013). Minimum age purchasing laws target both the seller and the buyer. In other words, should a firearm dealer sell a weapon to someone below the established minimum age, both the seller and the buyer are subject to criminal penalties. Some minimum age laws also set a minimum age that an individual must meet in order to legally be able to possess a firearm, even if that individual does not own the gun. Federal law sets the minimum age for handgun purchase (from unlicensed dealers) and handgun possession at 18. However, some states have minimum age requirements for purchase or possession that are more stringent than the federal standard. For the purpose of our study, we therefore measure minimum age laws for possession and purchase as dummy variables equal to 1 for all state-years in which a state had a law in place that was stricter than the federal law (and 0 otherwise). In almost all cases, when a

<sup>2</sup>The states with incomplete data, along with the number of missing observations, are as follows: Connecticut (10), Delaware (26), Hawaii (27), Maine (7), Massachusetts (6), Nebraska (1), New Hampshire (9), North Dakota (10), Rhode Island (29), South Dakota (3), Vermont (24), and Wyoming (4).

state's law was stricter than federal law, the minimum age was set at 21.

In Figure 2, we provide additional detail concerning the timing of state adoptions of CAP and minimum age laws. Specifically, the figure plots the number of states that have adopted CAP laws as well as state minimum age laws for purchase or possession (handguns) that exceed federal law. The figure clearly illustrates the limitations of the earliest studies of the effects of these laws due to the fact that they mostly relied on data observed prior to 2000. Because the late 1990s was a period of significant policy activity, the vast majority of evaluations of CAP laws and minimum age laws on youth suicide have therefore had to rely on a very limited post-treatment period.

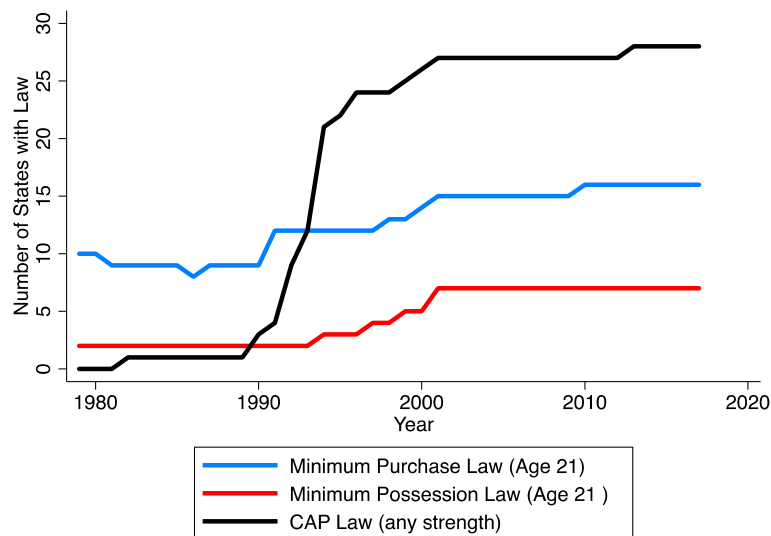
### Control variables

We estimate the effect of state CAP laws and minimum age laws while controlling for several potential confounding variables suggested in the literature. We include two indicators of state economic health—state per capita income and the state unemployment rate—to capture the stress-inducing effects of economic downturns on families and the subsequent effect this may have on youth suicides (Guis, 2015). Because divorce has been found to be related to psychological trauma in young people that can contribute to suicide (Bridge, Goldstein, & Brent, 2006), we follow other studies and control for the state divorce rate (Guis, 2015). We also include measures of the state black and Hispanic population due to the fact the suicide rate is highest for white, non-Hispanic people (Gius, 2015; Lott & Whitley, 2001; Rosengart et al., 2005; Webster et al., 2004). In addition, we control for state population density based on research which has found that

suicide rates are generally higher in rural areas (Fontanella et al., 2015). Using data recently compiled by the RAND Corporation (Schell et al., 2020), we control for the proportion of households in a state in which a member owns a firearm. Finally, we control for state government revenue per capita, which measures the capacity and potential willingness of states to provide social welfare and public health programs that may help mitigate some of the most important environmental stressors that contribute to youth suicide (Grogan et al., 2017; Ross et al., 2012).

### ESTIMATION AND RESULTS

The dependent variable for our analysis—the number of suicide deaths for people aged 24 and under—is a count outcome, and thus, ordinary least squares techniques are not appropriate as they may lead to inefficient, inconsistent, and biased estimates (Cameron & Trivedi, 2013). We therefore follow the lead of past studies of suicide deaths and use an estimation method that is more appropriate for event count data (Andrés & Hempstead, 2011; Cummings et al., 1997; Rosengart et al., 2005). Specifically, we utilize negative binomial regression, which unlike its simpler alternative, Poisson regression, allows for over-dispersion. In addition, estimation is complicated by the fact that we utilize panel data. We estimate our model using a lagged dependent variable to control for temporal dependence (Sen & Panjamapirom, 2012), and we report robust standard errors to determine statistical significance. Like several other studies, we also include state and year fixed effects to control for time-invariant state-specific effects as well as national forces (such as changes in federal law) that have a uniform effect across the states (Gius, 2015; Lott &



**FIGURE 2** Number of states adopting CAP and minimum age laws, 1979–2017

Source: Rand firearm database and tabulation by authors [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**TABLE 1** Negative binomial regression coefficient outputs for effect of minimum age laws and CAP laws on rate of youth suicide, 1980–2017

Independent variables	Firearm suicides		Nonfirearm suicides	
	Coeff.	IRR	Coeff.	IRR
Weak CAP law	-0.0130 [0.0169]		0.0446 [0.0349]	
Strict CAP law	-0.0754* [0.04159]	0.9273* [0.0386]	-0.0769 [0.0493]	
Minimum age 21—purchase	-0.0600*** [0.0221]	0.9418*** [0.0208]	-0.0401 [0.0422]	
Minimum age 21—possession	-0.1335*** [0.0516]	0.8751*** [0.0452]	0.0465 [0.0451]	
Per capita income	-0.0088 [0.0091]		-0.0053 [0.0120]	
Unemployment rate	-0.0077 [0.0066]		0.0109 [0.0075]	
Percent black	-0.0309*** [0.0078]	0.9696*** [0.0076]	-0.0495*** [0.0102]	0.9517*** [0.0098]
Percent hispanic	-0.0273*** [0.0045]	0.9731*** [0.0044]	-0.0366** [0.0051]	0.9641*** [0.0049]
Gun ownership rate	0.1930 [0.1807]		-0.5504*** [0.1720]	0.5767*** [0.0992]
Divorce rate	0.0074 [0.0098]		-0.0283** [0.0120]	0.9721** [0.0117]
Tax revenue per capita	-0.0171*** [0.0047]	0.9846*** [0.0046]	-0.0169*** [0.0055]	0.9832*** [0.0054]
Population density	-0.0013*** [0.0004]	0.9987*** [0.0004]	-0.0004 [0.0005]	
Lagged suicide deaths	0.0019*** [0.0003]		0.0004* [0.0002]	
LR test of alpha = 0: chibar2(01)	38.85**		19.83**	
Observations	1517		1517	

Note: Cell entries are negative binomial regression coefficients, with robust (state-clustered) standard errors in brackets. Incidence rate ratios (IRRs) are reported for variables that are statistically significant at the 0.10 level. Models include state and year fixed effects (not reported) and were estimated using the nbreg procedure in Stata 15.

\*\*\* $p < 0.01$ .

\*\* $p < 0.05$ .

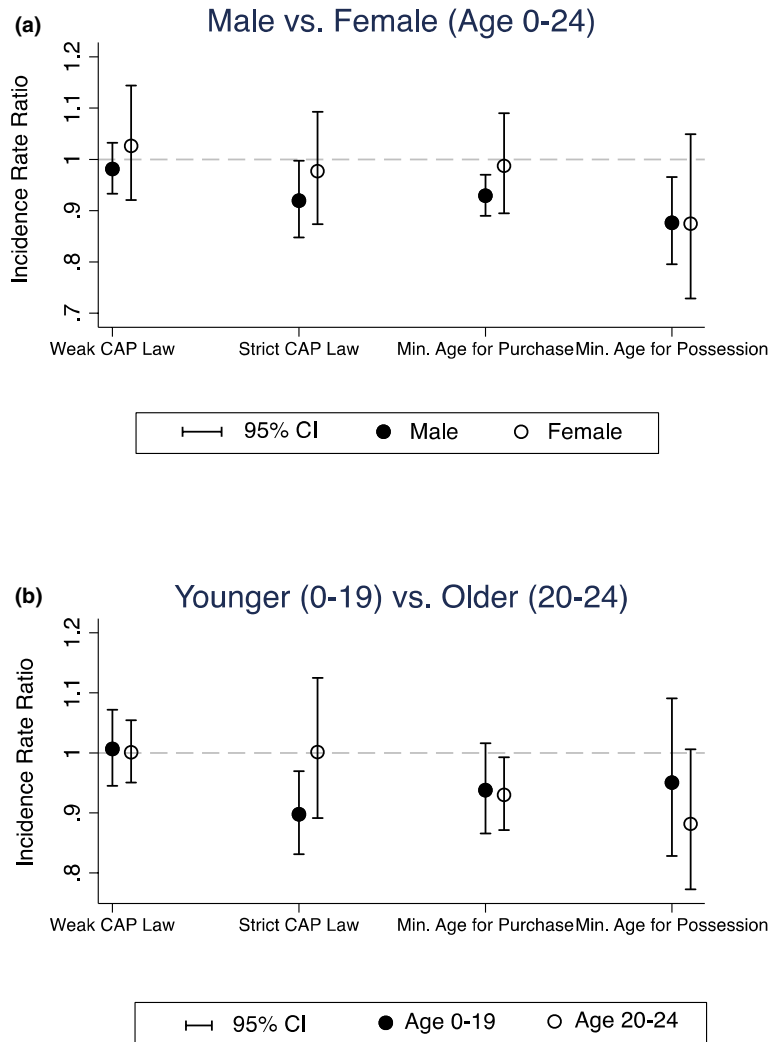
\* $p < 0.10$ .

Whitley, 2001; Rosengart et al., 2005). Finally, it is often appropriate in count models to specify an “exposure” variable that accounts for differing levels (across cases) in the amount of exposure to opportunities for the dependent variable to occur. We specify the size of a state's total population of people aged 24 and under as our exposure variable, which thus effectively transforms our dependent variable into the youth suicide rate.

We begin by estimating the effects of CAP laws and minimum age laws on all youth suicides by firearm (age 0–24). Table 1 displays the coefficient estimates and their standard errors. To provide a better substantive understanding of the coefficients reported in Table 1, we also present the associated incident rate ratio (IRR) for a one-unit increase in the independent variables that were found to be significantly related to suicide deaths (i.e.,  $p < 0.10$ ). For any independent variable  $X_i$ , the IRR reported in Table 1 is the ratio of the incidence of suicide when  $X_i = k + 1$  to the incidence rate when  $X_i = k$ . In other words, the incidence rate ratio reports the proportional change in the suicide rate when the independent variable of interest increases by one unit. For our policy variables, all of which are coded as dichotomous variables, the IRR thus represents the proportional change in the suicide rate due to implementing that policy.

We find that both types of minimum age laws (purchase and possession) have a negative, statistically significant effect on the youth suicide rates. States that raised the minimum age to purchase a handgun to 21 are estimated to have experienced a decrease of approximately 6% in the youth firearm suicide rate (compared to states that did not adopt such a law). The estimated effect of minimum age laws regulating possession of a handgun had a significantly larger effect. Our results show that raising the minimum age for possession to 21 led to a decrease of 13% in the youth firearm suicide rate. The effect of CAP laws is more mixed. Based on the coefficient estimates, we find that distinguishing between weak and strict laws does in fact matter. Not only is the coefficient estimate for strict CAP laws more than five times as large as the coefficient for weak CAP laws, but the effect of weak CAP laws—although negative—is not close to being statistically significant. On the other hand, the effect of strict CAP laws is statistically significant at the .10 level ( $p = 0.07$ ) and based on our estimates is predicted to have led to a decrease of approximately 8% in the youth firearm suicide rate in adopting states, compared to non-adopting states.

Thus far, the results generally provide support for advocates of CAP laws and minimum age laws as a strategy to reduce youth suicide rates. However, it is possible that the



**FIGURE 3** Effects of CAP laws and minimum age laws on youth suicide by firearm rates, by (a) gender and (b) age group. *Note.* The effects in the figure are incidence rate ratios estimated from negative binomial regressions estimated in a similar fashion as described in the text (state and year fixed effects, lagged dependent variable, and robust state-clustered standard errors). All models were estimated using the nbreg procedure in Stata 15 [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

reduction in firearm suicides due to the adoption of CAP laws and minimum age laws was offset to some degree by means substitution. We can investigate this possibility by estimating the effect of the same laws on nonfirearm suicide deaths. If the lack of access to handguns simply caused many youths to choose a different method of suicide, we would expect to see a positive effect of these laws on nonfirearm suicide deaths, as that would indicate that youths who may not be able to obtain access to a firearm are substituting firearms for a different method of suicide. To test this possibility, we replicated our model of firearm suicides using nonfirearm suicide deaths among the same target population (age 0–24) as the dependent variable. These results are reported under “Nonfirearm Suicides” in Table 1. These results are consistent with many other studies in that we find no evidence of means substitution. None of the four CAP law or minimum age policies had a significant effect on the nonfirearm suicide rate. In fact, for

three of the policies (weak and strict CAP laws and minimum age for purchase laws) the coefficient estimate was negative. This suggests that the effects of CAP laws and minimum age laws on firearm suicides also translated to a reduction in the overall youth suicide rate.

### ADDITIONAL EVIDENCE: SUICIDE RATES BY GENDER AND AGE

In addition to these results reported in Table 1, we conduct two additional analyses which compare the effects of CAP laws and minimum age laws across subgroups for which we have strong reason to believe the effects should vary. Should the results conform to these expectations, this would provide additional support for a causal interpretation of our findings. First, we compare the effects of CAP laws and minimum

age laws for males and females from the same population of youths aged 24 and under. As seen in Figure 1, males are far more likely to die from suicide in part due to the fact that males are far more likely to use a firearm as their method of choice (Andrés & Hempstead, 2011). Thus, we expect that the suicide-reducing effects of CAP laws and minimum age laws should be stronger for male youths compared to female youths. To test this hypothesis, we re-estimated our model of firearm suicide deaths separately for male and female youth, using the same control variables and estimation strategy as described above. Our estimates of the effects of CAP laws and minimum age laws by gender are reported in the top panel of Figure 3, which presents the estimated IRRs (and 95% confidence intervals) for each policy variable. The results for males are very similar to the effects reported for the combined sample in Table 1. That is, the effects of strict CAP laws (but not weak CAP laws) and minimum age laws for purchase and possession all had a negative, statistically significant ( $p < 0.05$ ) effect on male youth firearm suicide rates. In contrast, none of the laws had a statistically significant effect on female youth firearm suicides. This finding lends greater support for a causal interpretation of our main results as we would not expect gun laws to have much of an effect on female suicide rates since females are far less likely to use a firearm as their method of choice (Gius, 2015).

Our final analysis focuses on the effect of CAP laws. Due to the design of CAP laws, we have strong reason to believe that their effectiveness in reducing firearm suicides should vary across the age distribution for our sample of youths. States that implement the strictest CAP laws require that gun owners must safely secure their guns in their home and that they must not provide a gun to a minor, which under the stricter laws is defined as younger than 18. Young adults who are 18 or older are therefore far less likely than those who are younger than 18 to have their access to firearms restricted by CAP laws. Young adults (18 or older) are also less likely to be living at home with their parents compared to someone who is younger than 18. For this reason, young adults are therefore far less likely to experience spillover effects of secure storage requirements. If the effect of CAP laws that we have observed thus far is causal in nature, then we should see a difference in the effect of CAP laws if our sample of youths is disaggregated by age.

Unfortunately, the CDC data do not allow us to disaggregate the sample by age in a way that precisely conforms to our theoretical expectations. This is due to the fact that for our period of analysis the CDC mortality data are only available for 5-year age intervals. Nevertheless, we can split our sample into a way that should provide a meaningful test of this hypothesis. To do so, we created two samples—one for youth aged 19 and younger and one for young adults aged 20–24. We focus exclusively on males for this analysis based on our finding that the effect of CAP laws is primarily driven by its

effect on male firearm suicides. Our prediction is that if CAP laws are truly leading to a reduction of firearm suicides in our larger sample of youth aged 24 and under, the effect estimated for the 19 and under sample should be larger than the effect estimated for the older (20–24) sample. We have no expectations concerning how the effects of minimum age laws might vary across the two samples due to the fact that laws which raise the age for purchase and possession from 18 to 21 exclusively affect youths aged 18–20, and this population is split across our two sub-samples in this analysis.

We re-estimated our regressions separately for the two samples, once again specifying our models in the same way as described for our analysis presented in Table 1. Our estimates of the effects of CAP laws and minimum age laws by age-group are displayed in the bottom panel of Figure 3. Consistent with the previous analyses, we continue to find that weak CAP laws had no effect on firearm suicide rates, regardless of age. However, as expected, we find that strict CAP laws did have a statistically significant ( $p < 0.05$ ) negative effect for the sample of youths aged 19 and under, but we find no effect for the sample of youths aged 20–24. As for minimum age laws, we find that the point estimates are negative for both samples, but the estimates are somewhat stronger for the sample aged 20–24. This may be due to the fact the 18- to 19-year-old young adults are less likely to have moved out of their parents' home (compared to 20-year-old males) and therefore they may have less freedom to purchase and possess firearms. Regardless, the stark difference in the effect of CAP laws across the two samples provides further support for the claim that strict CAP laws do in fact reduce firearm suicides and that this effect is causal in nature.

## CONCLUSION

This study contributes to the literature on strategies to reduce youth suicide by providing an evaluation of the effects of two specific policies that have been implemented to reduce youth access to firearms—CAP laws and minimum age laws. Our study provides several important contributions to the literature on firearm policy and youth suicide. Using data that span a period of nearly four decades, we confirm the results reported by prior studies which have found that CAP laws have led to a reduction in firearm suicides (Gius, 2015; Webster et al., 2004). Yet, our analysis is the first to report that this finding is qualified by the fact that the design of state CAP laws matters. Across several different analyses, we find that weak CAP laws, which represent the majority of laws adopted by states, have little effect on youth firearm suicide rates. It is only in the minority of states that have adopted a relatively broad and more stringent CAP law that such laws have had a significant effect on youth firearm suicide. Thus, our results suggest that states that have not adopted all of the



policy provisions used to classify state CAP laws in our study could improve the effectiveness of their CAP law by adopting these additional provisions.

Our research is also the first to find that minimum age laws have been successful in reducing the rate of youth firearm suicide. Only a minority of states have adopted minimum age laws that set the legal age to purchase and possess a handgun at 21. Therefore, for many states this would seem to represent a very promising strategy to combat the rise in youth suicide rates. In contrast to our analysis of CAP laws, we did not measure the stringency of state minimum age laws. Therefore, future efforts could be directed toward measuring the stringency of minimum age laws to determine whether the design of such laws matters. Unfortunately, this may not be feasible unless more states adopt such laws that vary in stringency.

One important criticism of CAP laws and minimum age laws worth noting is that many advocates against higher threshold firearm policies believe that the laws do not have an effect on the overall rate of suicide. Opponents of CAP laws and minimum age laws believe that while these laws may have an effect on the rate of suicide by firearm, they cause an increase in the rate of suicide by other means, as individuals who cannot kill themselves with a firearm will resort to a different method when higher threshold policies are in effect. We explicitly tested this “means substitution” hypothesis by estimating the effect of CAP laws and minimum age laws on nonfirearm suicides. Our results fail to support this assertion as we find no evidence of a spike in nonfirearm suicides associated with the implementation of these gun laws. However, we cannot reject the means substitution hypothesis entirely. It is possible that restricting access to guns has led to an increase in nonfirearm, nonfatal suicide *attempts* due to the fact that firearms are far more lethal than any other suicide method. Even if this is the case, this does not change the fact that it appears that CAP laws and minimum age laws have at the very least resulted in a reduction in suicide *deaths*—which is the focus of this study.

Finally, our findings are generally consistent with studies of adult suicides, where research has found that policies limiting access to firearms for adults (e.g., background checks, waiting periods) have led to a reduction in the adult suicide rate (Anestis & Anestis, 2015; Anestis et al., 2015). Our research therefore provides support for the more general perspective that easy access to firearms has negative consequences for public health and that policy strategies that seek to limit access can provide important public health benefits. Nevertheless, our analysis finds that the mortality-reducing effects of CAP laws and minimum age laws have largely been concentrated among young males. This is not unexpected as many studies have documented the fact that males are far more likely to use guns as their suicide method of choice. Yet, the rate of female suicides has risen alongside that of males and

continues to represent an important public health problem. Indeed, between 2007 and 2017 the number of female youth suicide deaths more than doubled, with the majority of those suicides due to nonfirearm methods. Thus, while policies restricting firearms may have an important effect on reducing suicide, it is just one component of what must be a broader, more comprehensive policy strategy needed to combat this increasingly severe public health problem. In addition to laws that limit firearm access, this broader strategy should at the very least include greater investment in mental health access as well as programs that serve to buffer vulnerable populations from circumstances (e.g., economic dislocation) that may serve as catalysts for suicide.

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**How to cite this article:** Kappelman J, Fording RC. The effect of state gun laws on youth suicide by firearm: 1981–2017. *Suicide Life Threat Behav.* 2021;51:368–377. <https://doi.org/10.1111/sltb.12713>