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Guns, laws and public shootings in the United States

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ABSTRACT

Since the late 1990s, there have been increasing numbers of public shootings carried out with firearms in the United States. These tragedies continually renew the regulatory debate concerning public safety while considering civil liberties. Using a unique data set, we investigate whether laws correspond to whether an event occurs and the effects of event-specific characteristics on public shooting outcomes. In particular, we analyse how state-specific gun laws, the types of firearms, the shooting venues and the mental health of the gunman impact the outcomes of public shootings. Results show that most gun laws are unrelated to whether an event occurs. In addition, common state and federal gun laws that outlaw assault weapons are unrelated to the likelihood of an assault weapon being used during a public shooting event. Moreover, results show that the use of assault weapons is not related to more victims or fatalities than other types of guns. However, the use of hand guns, shot guns and high-capacity magazines is directly related to the number of victims and fatalities in a public shooting event. Finally, the gunman's reported mental illness is often associated with an increase in the number of victims and fatalities.

KEYWORDS

Guns; public shootings; gun control; gun laws

JEL CLASSIFICATION

K10; K40

I. Introduction

Public shootings prompt renewed debates about gun control with calls for legislation and regulations to limit the types and availability of firearms. After the shootings at Sandy Hook Elementary, President Obama vowed to 'use whatever power [his] office holds' to prevent future tragedies.[1] While most people would agree that preventing future tragedies is a worthy goal, policymakers disagree on the best course of action to take in order to achieve this goal. This comes as no surprise since there is little research on what policies or factors affect the outcomes of public shootings. However, given that shooting events are increasing over time (see Figure 1), this type of research is pertinent.

Although changes in gun legislation have been slow to evolve, in 2013 President Obama signed into law the Investigative Assistance for Violent Crimes Act of 2012. The act provided the attorney general the authority to assist in investigations of public shooting events occurring in a place of public use and active shooter events at the request of state law enforcement officials. On 5 January 2016, President Obama proposed an updated strategy to reduce gun violence in America. The strategy focuses on new background check requirements to increase the effectiveness of the National Instant Criminal Background Check System and to enhance the education and enforcement of existing state gun laws.[2] Some policymakers favour expanded gun legislation, such as an assault weapons ban, a limit on high-capacity magazines or expanded background checks. However, little is known about the effect of existing regulations on public shooting outcomes. Others point to mental illness as an explanation for these tragic events. Yet there is little research on how the presence of mental illness influences the outcomes of public shootings. This article addresses these unanswered questions. Indeed, the results from our study have important implications as policymakers move forward to prevent future tragedies.

While gun violence arises out of sociocultural, educational, behavioural and product safety issues which transcend simply gun ownership, gun

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[1]http://www.nytimes.com/2012/12/17/us/politics/bloomberg-urges-obama-to-take-action-on-gun-control.html
[2]http://www.ncsl.org/research/civil-and-criminal-justice/summary-president-obama-gun-proposals.aspx

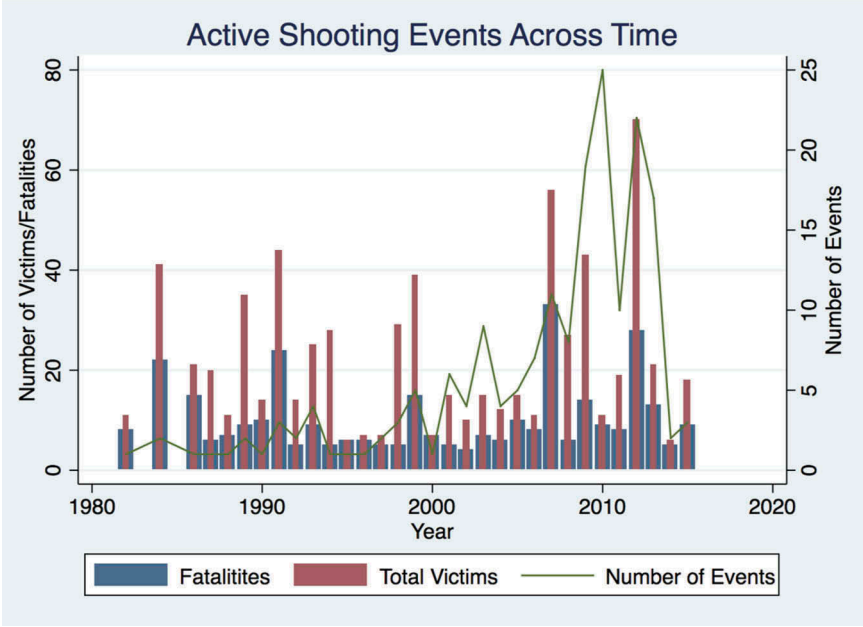

Figure 1. Distribution of events.

violence and, specific to the current analysis, many public shootings are arguably random events. Given the random and uncertain nature of tragic events like Sandy Hook, Aurora, Columbine and most recently at Umpqua Community College in October of 2015, the question arises as to whether or not public policy can have the same impact on a random act of mass violence as public policy has had on other areas of concern (Mozaffarian, Hemenway, and Ludwig 2013).

Policymakers across the political spectrum have variations of opinions on public policy and the impact the regulations or laws would have on the occurrence of these uncertain events. Some policymakers emphasize that a breadth of tougher gun laws would have prevented these random acts of violence or at the very least reduced the severity of the event. Counter to this argument, pro-gun or anti-control policymakers disbelieve gun controls have any preventive efficacy. Other pundits indicate the public shootings could have been prevented or the severity of the event would have been dramatically reduced through site-specific security. Given the breadth of the political debate and public opinion, the question still remains whether gun ownership regulation, gun and ammunition control, background checks and owner education have any effect on the damages caused by public shootings.

In this article, we analyse the outcomes of public shooting events using a unique panel data series of U.S. states from 1982 to 2014. The data include 184 public shootings over the last 31 years. Using these data, we create a state panel over time to test whether gun laws are associated with occurrences of public shootings. We find that most laws have little correlation with whether an event occurs. The one consistent finding is that state assault weapons laws show a negative correlation with active shooter events.

We then look at a cross section of public shootings to test whether gun laws, particularly laws that restrict or regulate weapons that are collectively classified in the National Firearms Act of 1968 (NFA) as assault-type weapons, impact whether assault weapons are used in public shootings. We find that state laws such as the NFA restrictions, as well as the federal assault weapons ban, have no effect on whether an assault weapon is used in a public shooting. In addition, using data on the weapons used in each public shooting, we analyse whether the types of guns as well as the number of guns used during a public shooting is associated with the resulting number of victims and fatalities. Our results indicate that assault weapons use is not associated with more victims or fatalities. Additional assault guns are also not associated with more victims than other types of guns and have no significant

relationship with fatalities. The use of high-capacity magazines, hand guns and shotguns, however, are consistently associated with more victims and more fatalities during a given public shooting.

Finally, we analyse whether the mental health status of the gunman affects the number of victims and fatalities. Our data contain information on whether the gunman had been diagnosed with mental illnesses, whether he had taken medication and whether he was currently off the medication at the time of the shooting. Overall, the mental health of the gunman is positively correlated with the number of victims and use of depression medication is positively correlated with both the number of victims and the number of fatalities.

This article provides an important contribution to our understanding about laws associated with public shootings and their outcomes. Many papers have researched the determinants of gun crime more broadly. For example, Duggan (2001) uses gun magazine subscriptions as a proxy for gun ownership to show that more guns are associated with increased crime. Other papers show that economic factors such as unemployment rates and incomes are associated with crime rates (Becker 1968; Corman and Mocan 2005; Gould, Weinberg, and Mustard 2002; Raphael and Winter-Ebmer 2001). Another strand of literature evaluates the effects of gun legislation on crime. Kwon et al. (1997), for example, find that states with restrictions such as licence requirements and waiting periods have fewer gun deaths, but the result is not significant in statistical terms. Lott and Mustard (1997) and Moody (2001) show that right to carry laws lead to less violent crime, but others find conflicting evidence (Ayres and Donohue 2003; Duggan 2001; Olson and Maltz 2001). In another study, Kwon and Baack (2005) form a comprehensive measure of gun control legislation and find that this measure is associated with fewer gun-related deaths. The objectives in these papers are focused solely on gun crime. We extend this literature by specifically examining the determinants and factors that affect whether a public shooting occurs and public shooting outcomes.

Other studies have examined public shootings. For instance, Chapman et al. (2006) look at the effects of broad gun reforms that removed semi-automatic guns, pump-action shotguns and rifles from civilian possession in Australia on gun violence, including public shootings. They find that the reforms were associated with a sharp decline in public shootings. Additionally, Duwe, Kovandzic, and Moody (2002) and Lott and Landes (2000) look at whether right to carry laws influence public shootings in the United States. Our analysis extends the literature by analysing a large panel to test the relation between many gun laws and public shootings. Our article also looks at whether state and federal assault weapon bans influence whether or not these types of weapons were used in the cross section of public shootings. Finally, our analysis extends previous work by looking at the cross-sectional data to estimate how event-specific characteristics influence the outcomes of public shootings.

This article proceeds as follows: Section II describes the data used in the analysis, Section III details the results, and Section IV concludes.

II. Data description

The shooting event data were obtained and cross-referenced from multiple publically available data sources.[3] We identify 184 shooting events between 1982 and October 2015 as mass shootings, spree shootings or active shooter events. We follow the FBI's definition in defining each type of shooting event. 'Mass' shootings are defined based on the following: (1) shootings were carried out by a single gunman, (2) shootings happened during a single incident and (3) shootings occurred in a public place with a minimum of four fatalities.[4,5,6] 'Spree' shootings are defined as (1) shootings were carried out by a single gunman, (2) shootings happened across multiple locations with no break in time between the shootings and (3) shootings occurred in a public place with a minimum of two fatalities.[4,5,6] An 'Active shooter' incident is defined as (1) an individual actively engaged in killing or attempting to kill people, (2)

[3]The Stanford Mass Shootings of America (MSA) data project, the Global Terrorism Database, a compiled data set by Follman, Aronson, and Pan (2012), and the Department of Justice's study on active shooter incidence in the United States.
[4]Serial Murder: A Multi-Disciplinary Perspective for Investigators. The Federal Bureau of Investigations. https://www.fbi.gov/stats-services/publications/serial-murder/serial-murder-july-2008-pdf.
[5]The exception of a 'single' gunman is the case of the Columbine massacre and the Westside Middle School killings, both of which involved two shooters.
[6]The gunman is excluded in the victim count.

shooting occurs in a confined/unconfined and populated area and (3) the subject's criminal actions involve the use of firearms.[7]

Data specific to the mass shooting include location (city and state), date of the mass shooting, the number of fatalities, the number of non-fatal victims and the venue of the mass shooting. Data specific to the gunman in the mass shooting include race, gender, age, prior signs of mental illness, known prescribed mental illness medication, prescribed medicine adherence at the time of the mass murder, suicide by the gunman, whether police killed the gunman and whether the gunman was arrested. Data specific to the weapons used in the mass murder include whether the weapon was obtained legally, the type of weapon used, the number of each type of weapon and the capacity of the ammunition magazine(s).

We obtain state-specific gun law data from each state's Department of Public Safety (or related department as the name varies by state), the United States Bureau of Alcohol, Tobacco, and Fire Arms and the United States Code of Federal Regulations (CFR) Title 27, Part 1 sub-chapter C. Nine different state-specific gun laws are included in our analysis as well as the federal ban on assault weapons. These are described in detail as follows.

Assault weapons ban

Federal regulation which bans the possess, import or purchase assault weapons or cosmetic features that would classify a firearm as an assault weapon, except for those already in lawful possession at the time of the law's enactment. The Federal Assault Weapons Ban of 1994 defined certain firearms as assault weapons based on the features they possessed (Public Safety and Recreational Firearms Use Protection Act, H.R.3355, 103rd Congress (1993–1994)).

Assault weapons law

The federal assault weapons ban expired in 2004; however, several states either fully adopted or have modified the definitions of the 2004 law. Seven states and the District of Columbia have enacted assault weapon bans or restrictions with various definitions and criteria.

Purchase permit

A certificate, identification card or other permit (terminology varies state by state) is required to acquire/purchase any lawful firearm.

Gun registration

Requires gun owners to record the ownership of their firearms with a designated law enforcement agency.

Licence requirement

Requires a state licence to possess a lawful firearm.

Concealed carry permit (CCW)

Permits the carry of a lawful firearm in public in a concealed manner on one's person or in close proximity. Requirements for CCW vary widely by state with a typical permit requiring residency, minimum age, submitting fingerprints, passing a computerized instant background check (or a more comprehensive manual background check), attending a certified handgun/firearm safety class, passing a practical qualification demonstrating handgun proficiency and paying a required fee.

Open carry

Permitting the carry of a lawful firearm in public in an open manner where a casual observer can observe an individual carrying a firearm. Similar to a CCW, requirements for open carry vary widely by state with a typical permit requiring the same standards listed above for CCW.

NFA restrictions

The National Firearms Act of 1968 defines a number of categories of regulated firearms which are collectively known as NFA firearms. These range from the

[7]A Study of Active Shooter Incidents in the United States between 2000 and 2013. The United States Department of Justice and the Federal Bureau of Investigation. https://www.fbi.gov/news/stories/2014/september/fbi-releases-study-on-active-shooter-incidents/pdfs/a-study-of-active-shooter-incidents-in-the-u.s.-between-2000-and-2013.

firing capacity (semi and full automatic) of a firearm, the length of the firearm barrel, suppression devices and ancillary devices considered destructive devices (i.e. grenades, bombs, explosive missiles, poison gas weapons and other comparable devices).

Peaceable journey law

Regulates the transport a firearm for any lawful purpose from any place where he may lawfully possess and carry such firearm to any other place where he may lawfully possess and carry the firearm if, during transportation, the firearm is unloaded, and neither the firearm nor any ammunition being transported is readily accessible or is directly accessible from the passenger compartment of such transporting vehicle.

Stand your ground

Legal concept that a person may justifiably use force in self-defence when there is reasonable belief of an unlawful threat at any location, without an obligation to retreat first. This is analogous to the Castle doctrine, stating that a person has no duty to retreat when their home is attacked.

Figure 1 shows the distribution of events in our data. The wide bars illustrate average fatalities over time, the narrow bars illustrate the average number of victims over time and the line illustrates the number of events over time. It is clear that the number of events has increased in recent history, although the severity of events as measured by the number of fatalities and victims does not show a clear trend.

Table 1 reports statistics that describe the sample of state-year data. We include all 50 states as well as Washington D.C.[8] With 51 states and 33 years of observable data, we have 1683 state-year observations. In addition to whether an event occurs, we also report *Population*, which is the state population according to the U.S. Census, and *Income*, which is the aggregate level of personal income gathered from the U.S. Bureau of Economics Analysis. We then create indicator variables that capture whether or not a state had one of each of the gun laws during a particular year.

Table 1. Summary statistics: panel data (obs. = 1683).

	Mean	Standard deviation	Min	Max
Active shooter event	0.09	0.29	0	1
Population (million)	5.39	6.01	0.45	38.8
Income (billion USD)	157	0.22	0.01	1.94
Year	1998	9.52	1982	2014
Purchase permit	0.27	0.45	0	1
Gun register	0.12	0.32	0	1
Assault law	0.13	0.33	0	1
Licence requirement	0.10	0.30	0	1
CCW permits	0.88	0.32	0	1
Open carry	0.71	0.46	0	1
NFA restrictions	0.39	0.49	0	1
Peaceable journey law	0.43	0.50	0	1
Stand your ground	0.78	0.42	0	1
AR-Ban	0.30	0.46	0	1

Table 1 shows that a shooting event occurred in approximately 9% of the state-year observations. The mean state population during that time was 5.39 million and aggregate personal state income totalled $157 million. The gun law indicators show for what fraction of state-year observations various gun laws held. For example, only 10% of the state-year observations had licence requirements while 88% of the observations required CCW permits.

For the 184 shooting events that occurred in the United States between 1982 and 2014, we also gather information particular to each event. This information is summarized in Table 2. Outcome variables include the number of individuals that were injured or killed (*Victims*) and the number of fatalities (*Fatalities*). Explanatory variables include the age of the gunman (*Age*), an indicator variable capturing whether the gunman was a minority (*Minority*) and an indicator variable for whether there were reported signs that the gunman suffered from possible mental illness (*Mental Illness*). We also gather data on the venue of the mass shooting. *School* and *Workplace* are indicator variables for whether the mass shooting occurred at a school or workplace. To examine cultural influences on violence, we include a variable *Culture of Honour* defined by states in the Southern United States which are considered honour states. A culture of honour is a culture where people avoid intentionally offending others and maintain a reputation for not accepting improper conduct by others. Brown et al. (2009) show that culture of honour states are more likely to have students carry weapons to school and are more likely to experience school shootings.

[8]We note that results reported in this study are qualitatively similar when we exclude Washington D.C. and just use the 50 states.

Table 2. Summary statistics: cross-sectional data (obs. = 184).

	Mean	Standard deviation	Min	Max
Victims	8.82	9.73	0	70
Fatalities	4.23	4.72	0	33
Age	36.64	15.14	12	89
Minority	0.36	0.48	0	1
Mental Illness	0.46	0.50	0	1
Use Depression Med	0.14	0.35	0	1
Off Depression Med	0.09	0.29	0	1
School	0.22	0.42	0	1
Workplace	0.54	0.50	0	1
Culture of Honour State	0.67	0.47	0	1
Year	2006.14	7.16	1982	2015
Arrested	0.37	0.48	0	1
Police	0.20	0.40	0	1
Legal Gun	0.87	0.34	0	1
#Guns	1.80	1.19	1	9
#Handguns	1.05	0.79	0	4
#Revolvers	0.14	0.49	0	5
#Shotguns	0.28	0.52	0	2
#Assault Guns	0.34	0.53	0	2
D_Handguns	0.78	0.41	0	1
D_Revolvers	0.11	0.31	0	1
D_Shotguns	0.24	0.43	0	1
D_Assaultguns	0.31	0.46	0	1
High Capacity Magazine	0.37	0.48	0	1
Purchase Permit	0.38	0.49	0	1
Gun registration	0.22	0.42	0	1
Assault weapon law	0.26	0.44	0	1
Licence requirement	0.08	0.27	0	1
CCW permits	0.84	0.37	0	1
Open carry	0.83	0.38	0	1
NFA restrictions	0.48	0.50	0	1
Peaceable journey laws	0.34	0.47	0	1
Stand your ground	0.83	0.38	0	1

From various reports, we also obtain data on the guns used during the mass shooting. *Legal Gun* is an indicator variable for whether the gun (or guns) used by the gunman at the mass shooting was obtained legally. Specifically, *Legal Gun* includes (according to state law) if the firearm(s) was/were registered, if a permit was required for ownership and/or if a licence was required for ownership. As part of the legal purchase of a firearm, FBI instant background checks are required of all purchasers. The expectation to the background check regulation is the Private Sale Exemption, otherwise known as the widely debated 'Gun Show Loophole'. Under federal law, private-party sellers are not required to perform background checks on buyers, record the sale or ask for identification. However, according to a National Institute of Justice, the research arm of the U.S. Department of Justice, study, only 2% of criminal guns come from gun shows.[9] As of September 2015, 18 states and Washington D.C. have background check requirements beyond federal law. Eight states require universal background checks at the point of sale for all transfers, including purchases from unlicensed sellers.

More detailed weapon information reported in Table 2 includes the total number of guns at the scene (*#Guns*), the number of handguns (*#Handguns*), the number of revolvers (*#Revolvers*), the number of shot guns (*#Shotguns*) and the number of assault weapons (*#Assault Guns*).[10,11] We also create indicator variables for the various gun types used in the sample of mass shootings. *D_Handgun, D_Revolvers, D*_Shotguns and *D_Assaultguns* indicate that a hand gun, revolver, shot gun or assault weapon was used during the mass shooting, respectively. In addition to the gun types, we create an indicator variable for whether a high-capacity magazine (*High Capacity Magazine*) was used. We define a high-capacity magazine according to the commonly accepted definition used under the United States' Federal Assault Weapons Ban, which expired in 2004, as a magazine capable of holding more than 10 rounds of ammunition. In addition to the information about the gun types, Table 2 also includes indicator variables that capture the nine common gun laws in each state where a mass shooting occurred.

Table 2 shows that the mean number of victims is 8.82 while the mean number of fatalities is 4.23. We note that the minimum number of fatalities is 0.00 as we have included not only mass and spree shootings but active shooter incidences which by definition do not require a fatality. The average age of a gunman is slightly over 36. Approximately 36% of gunmen were minorities and more than 46% of gunmen had possible signs of mental illness. This latter summary statistic suggests that policymakers and regulators might attempt to address mental health issues in an attempt to deter the number of active shooting incidences. We further explore this possibility below.

[9]Homicide in eight US cities: Trends, Context, and Policy Implications. National Institute of Justice, U.S. Department of Justice. https://www.ncjrs.gov/pdffiles1/ondcp/homicide_trends.pdf.

[10]Handgun (27 CFR 478.11). (a) Any firearm which has a short stock and is designed to be held and fired by the use of a single hand; and (b) Any combination of parts from which a firearm described in paragraph (a) can be assembled.

[11]Revolver (27 CFR 478.11). A weapon originally designed, made, and intended to fire a projectile (bullet) from one or more barrels when held in one hand, and having (a) a chamber(s) as an integral part(s) of, or permanently aligned with, the bore(s); and (b) a short stock designed to be gripped by one hand and at an angle to and extending below the line of the bore(s).

Table 2 also shows that 22% of active shooter events occurred at schools and 54% occurred at places of work. The remaining 24% of events did not occur at one of these two venues. We found that 67% of active shooter incidences occurred in states which are considered to have a culture of honour. In Table 2, we also find that 87% of guns used in the cross section of mass shootings were obtained legally. The average total number of guns used by a gunman is 1.80, the average number of handguns used is 1.05, the average number of revolvers used is 0.14, the average number of shotguns used is 0.28 and the average number of assault weapons used is 0.34. These simple statistics suggest that hand guns are used the most and nearly three times as much as assault weapons, which is the second most commonly used gun type in the sample. When examining the gun-type indicator variables, at least one hand gun was used 78% of the time, while revolvers were used 11% of the time, shotguns were used 24% of the time and assault weapons were used approximately 31% of the time. High-capacity magazines were used in 37% of active shooter events.

Table 2 also reports the summary statistics for the nine common state gun laws that were in existence during the year the mass shooting occurred. We find that nearly 38% of events took place in states that required purchase permits, 22% in states that required the registration of fire arms, 26% in states that had an assault weapons law, 8% in states that had licence requirements, 84% in states that had conceal and carry permit laws, 83% in states that had open carry laws, 48% in states that had restrictions on NFA-classified weapons, 34% in states that had peaceable journal laws and 83% in states that had stand your ground laws and the time of the mass shooting.

III. Empirical results

In this section, we present our empirical results. First, we examine how state-specific characteristics such as population, income and gun laws affect the likelihood of an active shooter event in a particular state during a particular year. Second, we determine whether certain gun laws targeting the prohibition of assault weapon use affect the likelihood that assault weapons were used in an active shooter event. Third, we examine cross-sectional factors that explain the number of victims and the number of fatalities during an event by focusing on the types of guns used by the gunman as well as the mental health of the gunman.

Predictors of mass shootings

We begin by examining characteristics that influence the likelihood of an active shooter event in a particular state during a particular year. Utilizing the panel data set described above, we estimate the following equation with a probit regression.

$$Event_{i,t} = \gamma_0 + \theta_{j,i,t}\sum_{j=1}^{10} GunLaws_{i,t} + \gamma_1 PersIncome_{i,t} + \gamma_2 Population_{i,t} + \gamma_3 Year_t + \varepsilon_i + \eta_{i,t} \quad (1)$$

Event is equal to one if an active shooter event occurred in state i during year t, zero otherwise. The independent variables include nine indicator variables that capture whether a particular gun law existed in state i during year t as well as a dummy variable capturing the time period when the federal ban on assault rifles existed from September 1994 to September 2004 (*AR-Ban*). We also include state aggregated personal income in $ billions (*Income*) and state population in millions (*Population*). In order to control for any time trend in active shooter events, we include a count variable *Year*, which equals the year of a particular observation. Finally, we include state fixed effects to account for omitted time invariant variables (ε_i).

Table 3 reports the marginal effects from estimating variations of Equation (1) with robust standard errors clustered by state. Column 1 reports the probit regression results when we only include the gun law indicator variables. The first important result is that 7 of the 10 indicator variables produce estimates that are not statistically different from zero. We note that the indicator variable *Assault Law* produces a negative and significant coefficient while *AR-Ban and Stand Your Ground* produce positive and significant estimates. These results indicate that state assault weapon bans are associated with a lower likelihood of an active shooter event while the federal assault weapons ban and stand your ground laws are associated with an increase in the probability of an event. When we

Table 3. Determining active shooter events: effect of gun laws.

	1	2	3
AR-Ban	0.078**	0.004	−0.068**
	(0.034)	(0.020)	(0.032)
Assault Law	−0.042***	−0.022*	−0.045**
	(0.016)	(0.012)	(0.018)
Purchase Permit	−0.006	−0.024	0.372
	(0.036)	(0.016)	(0.358)
Gun register	0.059	−0.007	0.115
	(0.061)	(0.018)	(0.139)
Licence requirement	−0.047	−0.003	−0.271
	(0.033)	(0.017)	(0.207)
CCW permits	−0.034	−0.020	0.276
	(0.048)	(0.022)	(0.258)
Open carry	−0.021	0.010	0.312
	(0.030)	(0.011)	(0.289)
NFA restrictions	−0.004	0.017	0.346
	(0.033)	(0.018)	(0.288)
Peaceable journey law	−0.017	−0.010	−0.404
	(0.024)	(0.012)	(0.350)
Stand your ground	0.050**	−0.004	−0.181***
	(0.022)	(0.019)	(0.044)
Income (billion USD)		−0.023	0.688***
		(0.066)	(0.238)
Population (million)		0.008***	−0.020
		(0.002)	(0.022)
Year		0.006***	0.004***
		(0.001)	(0.001)
State fixed effects	No	No	Yes
Observations	1683	1683	1683

The dependent variable is an indicator for an active shooter event. Coefficients in columns 1 and 2 represent marginal effects from probit regressions. Column 3 provides the coefficients from a linear probability model. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

include controls for population and personal income in column 2, the estimates on the *AR-Ban* and *Stand Your Ground* indicator variables are no longer significant. Further, the coefficient on *Assault Law* is only marginally significant. Again, none of the other seven indicator variables produces a significant coefficient. We note, however, that the estimates for *Population* and *Year* are positive and significant in column 2, reflecting the fact that incidents occur in states with higher populations and have increased over time.

Column 3 presents the results from a linear probability model where we include state fixed effects.[12] A few results are noteworthy. First, we find that the coefficient on *Stand Your Ground* becomes negative and significant at the 0.01 level while the coefficients on *AR-Ban* and *Assault Law* are negative significant at the 0.05 level. We also find that, when controlling for state fixed effects, *Income* and *Year* produce positive and significant coefficients while *Population* does not. Combined, the results in Table 3 show that any effect that gun laws have on the likelihood of an active shooter outcome depends on the econometric specification. Further, many of the gun laws analysed in the table have no effect on the probability of an event. The only estimate that is consistently negative is the coefficient on state assault weapons laws. These results might contribute to policy debate about the effectiveness of gun laws on active shooter events.

Gun laws and weapon choice

Next, we examine whether gun laws, including the Federal Assault Weapons Ban, affected the use of assault weapons during an active shooter event. Using the cross-sectional data, we estimate the following equation:

$$\begin{aligned} AR\_used_i = {} & \gamma_0 + \gamma_1 AR - Ban_t + \gamma_2 Assault\ Law_t \\ & + \gamma_3 Age_i + \gamma_4 Minority_i + \gamma_5 School_i \\ & + \gamma_6 Workplace_i + \gamma_6 Cutlure\ of\ Honour \\ & State_i + \gamma_7 Mental\ Illness_i + \gamma_8 LegalGun_i \\ & + \gamma_9 Year_t + \theta_{j,i,t} \sum_{j=1}^{8} GunLaw_{i,t} + \eta_i \end{aligned} \tag{2}$$

Here, the dependent variable is equal to unity if an assault weapon was used during an event and zero otherwise. The independent variables of interest are an indicator variable capturing the period when the Federal Assault Weapons Ban existed (September 1994 to September 2004) as well as an indicator variable capturing whether the state in which the event occurred had an assault weapons law. Other control variables include characteristics of the gunman and the venue, such as *Age, Year*, and indicator variables for *Minority, School, Workplace, Culture of Honour State, Mental Illness* and *Legal Gun*. We also include eight indicator variables that capture the remaining state gun laws.

Table 4 reports the results from estimating Equation (2) using probit regressions. We report the marginal effects from the probit estimates as well as robust standard errors. In column 1, we only include the indicator variables *AR-Ban* and *Assault Law*. The estimates are statistically insignificant, indicating that neither the federal assault weapon ban nor state assault weapon bans affect the probability that assault weapons are used in an active shooter event. In column 2, we include control

[12]We use a linear probability model instead of a probit given the biases and inconsistency found in fixed effects estimators for non-linear models (see Greene 2004).

Table 4. Determinants of the use of assault weapons.

	1	2	3	4
AR-Ban	−0.161	−0.157	−0.226	−0.233
	(0.162)	(0.169)	(0.181)	(0.182)
Assault Law	0.192	0.201	0.167	0.218
	(0.199)	(0.210)	(0.232)	(0.246)
Age		−0.001		−0.002
		(0.003)		(0.003)
Minority		−0.082		−0.090
		(0.073)		(0.074)
School		0.079		0.082
		(0.114)		(0.119)
Workplace		0.018		0.010
		(0.088)		(0.088)
Culture of Honour State		0.024		0.061
		(0.074)		(0.090)
Mental Illness		0.072		0.045
		(0.069)		(0.071)
Legal Gun		0.008		−0.005
		(0.103)		(0.101)
Year		−0.006		−0.004
		(0.005)		(0.005)
Purchase Permit			0.214*	0.202
			(0.124)	(0.138)
Gun register			0.003	−0.034
			(0.124)	(0.135)
Licence requirement			−0.046	0.069
			(0.158)	(0.194)
CCW permits			0.021	0.014
			(0.111)	(0.116)
Open carry			−0.090	−0.041
			(0.117)	(0.123)
NFA restrictions			−0.083	−0.099
			(0.121)	(0.123)
Peaceable journey law			0.051	0.019
			(0.098)	(0.097)
Stand your ground			0.162*	0.191**
			(0.083)	(0.082)
Wald	0.98	6.19	9.91	14.95
p-Value	0.613	0.721	0.449	0.599
Observations	184	184	184	184

Coefficients represent marginal effects from probit regressions. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

variables for characteristics of the gunman and venue as well as the variable *Year*. Again, we do not find that either federal laws or state laws affect the use of assault weapons. We also note that none of the control variables are significantly different from zero. Column 3 includes additional indicator variables capturing the other eight common state gun laws. Again, we do not find that *AR-Ban* and *Assault Law* produce significant estimates. We do, however, find that *Purchase Permit* and *Stand Your Ground* produce positive and significant coefficients. Column 4 reports the results of the full model. When including the control variables that capture the characteristics of the gunman and venue, the estimate for *Purchase Permit* is no longer significant. However, the coefficient on *Stand Your Ground* remains positive and significant, suggesting that states with stand your ground laws were more likely to have an active shooter event where the shooter used an assault weapon. Perhaps more importantly, neither *AR-Ban* nor *Assault Law* produce significant coefficients. Overall, the results in Table 4 support the idea that gun laws targeting the restriction of assault weapons do not impact whether these weapons are used during an active shooter event.

Explaining the number of victims and fatalities: gun characteristics

In this section, we attempt to identify factors that influence the number of victims and the number of fatalities in an active shooter event. In particular, we examine the effect of the number and types of guns used on the number of victims and fatalities. We also include a variety of control variables that might provide some important inferences. We estimate the following equation using our cross-sectional sample of active shooter events:

$$\begin{aligned} Victims/Fatalities_i = {} & \beta_0 + \beta_1 Legal\,Gun_i \\ & + \beta_2 D\_Hand\ guns_i \\ & + \beta_3 D\_Revolvers_i \\ & + \beta_4 D\_Shotguns_i + \beta_5 D\_Assault_i \\ & + \beta_6 High\ Capacity\ Magazine_i \\ & + \beta_7 Age_i + \beta_8 Minority_i \\ & + \beta_9 School_i + \beta_{10} Workplace_i \\ & + \beta_{11} Culture\ of\ Honour\ State_i \\ & + \beta_{12} Mental\ Illness_i \\ & + \beta_{13} Arrested_i + \beta_{14} Shot\ by \\ & Police_i + \beta_{15} Year_i + \varepsilon_i \end{aligned} \tag{3}$$

The dependent variable is either the number of victims (*Victims*) or the number of fatalities (*Fatalities*) during an event. Independent variables of interest include *Legal Gun, D_Handguns, D_Revolver, D_Shotguns, D_Assault* and *High Capacity Magazine*. Additional control variables include *Age* and the indicator variables for *Minority, School, Workplace, Culture of Honour State* and *Mental Illness*. In addition to the demographic information about the gunman and the venue, we also control for the outcome of the event. *Arrested* is an indicator variable for whether the gunman was arrested. *Shot by Police* is an indicator variable for whether the gunman was shot by

police officers. The omitted dummy category consists of cases when the gunman committed suicide. As before, we also control for *Year*.

Since the dependent variables are discrete count variables, we use negative binomial regressions. While the Poisson regression also allows for consistent estimates using count data, the Poisson model makes more restrictive distributional assumptions than the negative binomial model by requiring means and variances to be equal. The summary statistics of both *Victims* and *Fatalities* in Table 2 show that the variances of both *Victims* and *Fatalities* are much larger than the means, suggesting that the dependent variables are over-dispersed. Therefore, we report the results from the negative binomial regressions along with robust standard errors in Table 5, although we note that qualitatively similar results are found when we use Poisson regressions to estimate Equation (3).

Column 1 shows the results from a simple regression where the dependent variable is *Victims* and the only independent variable is the indicator variable *Legal Gun*. We do not find that *Legal Gun* produces an estimate that is significantly different from zero. In column 2, we include indicator variables for each of the gun types. We find that the estimates for each of the indicator variables produce positive estimates that are statistically different from zero. However, we cannot reject the null that the coefficients are equal to each other. This suggests that there is not one type of gun that causes more victims than another. In column 3, we estimate a simple regression where we only include the indicator variable *High Capacity Magazine* and find that the estimate is positive and statistically significant. In column 4, we find that *D_Handguns* and *D_Shotguns* retain their positive and significant estimates, but the coefficients on *D_Revolvers* and *D_Assault* do not. Moreover, the coefficient on *D_Assault* is statistically lower than the coefficients on *D_Handguns* and *D_Shotguns* and the coefficient on *D_Revolvers* is statistically lower than the coefficient on *D_Shotguns*. We also note that *High Capacity Magazine* produces a positive and significant estimate, which is similar to the simple regression in column 3. A few other results are noteworthy. We find significantly negative

Table 5. Determining the number of victims and fatalities: effect of gun types.

	Dependent variable: victims				Dependent variable: fatalities			
	1	2	3	4	5	6	7	8
Legal Gun	−0.122			0.118	−0.242			0.011
	(0.222)			(0.143)	(0.250)			(0.181)
D_Handguns		0.430**		0.386***		0.431**		0.437***
		(0.173)		(0.141)		(0.189)		(0.168)
D_Revolvers		0.288**		0.143		0.541***		0.330***
		(0.138)		(0.125)		(0.129)		(0.119)
D_Shotguns		0.443***		0.620***		0.391**		0.605***
		(0.170)		(0.132)		(0.181)		(0.161)
D_Assault		0.373**		−0.083		0.097		−0.234
		(0.160)		(0.152)		(0.172)		(0.185)
High Capacity Magazine			0.591***	0.478***			0.403**	0.388**
			(0.154)	(0.147)			(0.166)	(0.164)
Age				−0.009***				−0.004
				(0.003)				(0.004)
Minority				−0.074				0.068
				(0.114)				(0.142)
School				−0.393**				−0.570***
				(0.191)				(0.219)
Workplace				−0.517***				−0.719***
				(0.134)				(0.136)
Culture of Honour State				0.072				−0.046
				(0.105)				(0.137)
Mental Illness				0.339***				0.261**
				(0.113)				(0.131)
Arrested				−0.186				−0.598***
				(0.119)				(0.137)
Shot by Police				−0.246*				−0.441***
				(0.136)				(0.171)
Year				−0.034***				−0.031***
				(0.007)				(0.008)
Observations	184	184	184	184	184	184	184	184

Coefficients from negative binomial regressions. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

coefficients for *Age, School, Workplace, Shot by Police* and *Year* and a positive and significant coefficient on the indicator variable *Mental Illness*. This latter finding suggests that mentally ill gunman generally inflict injury upon a greater number of individuals. The negative coefficient on *Year* suggests that while the likelihood of events has increased over time the severity as measured by victims and fatalities has decreased.

To determine the economic magnitude of any of the estimated coefficients, we transform the negative binomial estimate into percentage differences using the expression $100 \times \{\exp(\beta_j) - 1\}$, where β_j is one of the j estimated coefficients from Equation (3). Focusing on column 4, the use of this expression for the estimated coefficient for, say, *D_Handguns*, we find that when a handgun is used by a gunman, the number of victims increases approximately 47%. When shotguns or high-capacity magazines are used, the number of victims increases by 86% or 61%, respectively. Further, mentally ill gunmen generally have a 40% higher number of victims than non-mentally ill gunman.

The results in column 4 provide some important insights into the outcomes of active shooter events. First, we find that mental illness and high-capacity magazines are positively correlated with the number of victims during these types of incidents. Second, while handguns and shotguns also correlated with the number of victims, assault weapons are not. Third, younger shooters, at places other than schools or workplaces, generally have a higher number of victims. Lastly, we find that, in cases where the gunman is shot by police, the number of victims decreases by nearly 28%.

Columns 5–8 report the results when the number of fatalities is used as the dependent variable. Results in columns 5–7 are generally similar to those in the full model (column 8), so, for brevity, we only discuss the findings in column 8. We also find that the conclusions that we draw in column 4 are somewhat similar to those in column 8. For instance, *D_Handguns, D_Shotguns, High Capacity Magazines* and *Mental Illness* produce positive estimates while *School, Workplace, Shot by Police* and *Year* produce negative coefficients. However, we also find a significantly positive estimate on *D_Revolvers* and a significantly negative estimate on *Arrested*. Focusing on the magnitude of the coefficients in column 8 to the corresponding coefficients in column 4, the economic significance seems to be similar between columns.[13,14]

Next, we extend our analysis by examining the number of guns and gun types instead of looking only at the whether a particular type of gun was used in the mass shooting. To do so, we estimate a variant of Equation (3) as follows:

$$\begin{aligned} Victims/Fatalities_i = {} & \beta_0 + \beta_1 \# Gun_i \\ & + \beta_2 \# Hand\ guns_i \\ & + \beta_3 \# Revolvers_i \\ & + \beta_4 \# Shotguns_i + \beta_5 \# Assault_i \\ & + \beta_6 Age_i + \beta_7 Minority_i \\ & + \beta_8 School_i + \beta_9 Workplace_i \\ & + \beta_{10} Culture\ of\ Honour\ State_i \\ & + \beta_{11} Mental\ Illness_i \\ & + \beta_{12} Arrested_i + \beta_{13} Shot\ by \\ & Police_i + \beta_{14} Year_i + \varepsilon_i \end{aligned} \tag{4}$$

In Equation (4), the dependent and independent variables are the same as in Equation (3) with one exception. Instead of including indicator variables for gun types, in Equation (4) we include the total number of guns (*#Guns*), the number of handguns (*#Handguns*), the number of revolvers (*#Revolvers*), the number of shotguns (*#Shotguns*) and the number of assault weapons (*#Assault Guns*). The results are reported in Table 6. For brevity, we will discuss the results from the full models in columns 3 and 4 and columns 7 and 8. In column 3, we find that, after controlling for a variety of independent variables, the estimate for *#Guns* is significantly positive. In economic terms, a unit increase in the number of guns is associated with a 21.7% increase in the number of

[13] As a measure of robustness, we estimate Equation (3) using a different definition for assault weapons. Instead of the definition used for Assault Weapons according to FBI reports, we redefine Assault Weapons using a broader definition that has been used in a bill that was introduced 24 January 2013 that would impose various bans on assault weapons. Results from these tests again show that whether a gun that was used under this alternative definition is unrelated to the number of injured victims or the number of fatalities.

[14] As another measure of robustness, instead of including an indicator variable for the use of high-capacity magazines, we include the number of guns that were used with high-capacity magazines. These unreported tests also show a direct relation between the number of guns with high-capacity magazines and the number of injured victims as well as the number of fatalities. The results from these tests are available upon request from the authors.

Table 6. Determining the number of victims and fatalities: effect of the number of guns.

	Dependent variable: victims				Dependent variable: fatalities			
	1	2	3	4	5	6	7	8
#Guns	0.268***		0.196***		0.228***		0.178***	
	(0.072)		(0.058)		(0.068)		(0.057)	
#Handguns		0.300***		0.258***		0.288***		0.247**
		(0.095)		(0.078)		(0.109)		(0.097)
#Revolvers		0.051		−0.047		0.238		0.104
		(0.095)		(0.066)		(0.169)		(0.067)
#Shotguns		0.331**		0.362***		0.285*		0.369***
		(0.135)		(0.114)		(0.152)		(0.135)
#Assault Guns		0.323**		0.189*		0.081		−0.006
		(0.133)		(0.100)		(0.132)		(0.127)
Age			−0.010***	−0.010***			−0.005	−0.005
			(0.003)	(0.003)			(0.005)	(0.004)
Minority			−0.053	−0.000			0.128	0.161
			(0.128)	(0.125)			(0.153)	(0.148)
School			−0.484**	−0.514***			−0.645***	−0.668***
			(0.201)	(0.194)			(0.217)	(0.207)
Workplace			−0.648***	−0.669***			−0.811***	−0.833***
			(0.152)	(0.148)			(0.141)	(0.138)
Culture of Honour State			0.032	0.051			−0.076	−0.073
			(0.110)	(0.107)			(0.145)	(0.139)
Mental Illness			0.326***	0.338***			0.251*	0.273**
			(0.120)	(0.118)			(0.141)	(0.136)
Arrested			−0.165	−0.153			−0.581***	−0.585***
			(0.131)	(0.124)			(0.145)	(0.140)
Shot by Police			−0.200	−0.216*			−0.376**	−0.389**
			(0.139)	(0.130)			(0.178)	(0.168)
Year			−0.026***	−0.029***			−0.025***	−0.026***
			(0.007)	(0.007)			(0.007)	(0.007)
Observations	184	184	184	184	184	184	184	184

Coefficients from negative binomial regressions. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

victims. The other control variables produce coefficients that are similar in sign and magnitude to the corresponding coefficients in the previous table. In column 4, we find that the estimates for *#Handguns, #Shotguns* and *#Assault Guns* produce estimates that are positive and significant at the 0.10 level or lower. In economic terms, a unit increase in the number of handguns, shotguns and assault weapons is associated with a 29%, 44% and 21% increase, respectively, in the number of victims. In this case, we cannot say that assault guns have a statistically different impact on victims than the other types of guns.

Columns 5–8 report the results when the dependent variable is the number of fatalities. We report that while *#Handguns* and *#Shotguns* produce positive and significant estimates, *#Assault Guns* does not. In addition, the coefficient on *#Assault Guns* is statistically lower than the coefficients on *#Handguns* and *#Shotguns*. We still observe negative coefficients on the indicator variables for *School, Workplace, Arrested, Shot by Police* and *Year*. Further, the estimate for *Mental Illness* is positive and significant. Results in this subsection have interesting and important implications. First, the use of assault weapons is not necessarily associated with more injuries or more deaths in our cross section of active shooter events. Instead, the use of handguns and shotguns is more highly correlated with the number of victims/fatalities. Second, mentally ill gunmen have a higher number of victims and fatalities than non-mentally ill gunmen. Third, law enforcement (in terms of arresting the gunmen or shooting the gunmen) is associated with a decrease in the number of victims/fatalities. The inferences from these tests are likely to contribute to the ongoing gun policy debate.[15]

Explaining the number of victims and fatalities: mental health characteristics

In Table 2, we found that 46% of the individuals responsible for active shooter events in the United States showed possible signs of mental illness according to various reports. Further, our findings in Tables 5 and 6 seem to indicate that mental illness is associated

[15]As mentioned in footnote 6, we use an alternative definition for assault weapons according to a bill voted on by the U.S. senate on 24 January 2013. Using this alternative definition for assault weapons, we are able to draw similar conclusions to those drawn in Table 6.

with a higher number of victims/fatalities. Given these statistics, we provide a more thorough examination of the role that mental illness plays in explaining the total number of victims and the number of fatalities. We not only examine reports of possible signs of mental illness, but we also gather information about the types of medication the gunman was prescribed and whether or not the gunman was on or off the prescribed medication at the time of the mass shooting.

We estimate the following equation using our cross-sectional sample of active shooter events:

$$\begin{aligned} Victims/Fatalities_i = {} & \beta_0 + \beta_1 MentalIll_i \\ & + \beta_2 Use\,DepMed_i \\ & + \beta_3 OffDepMed_i \\ & + \beta_4 Age_i + \beta_5 Minority_i \\ & + \beta_6 School_i + \beta_7 Workplace_i \\ & + \beta_8 Culture\ of\ Honour\ State_i \\ & + \beta_8 Arrested_i + \beta_9 PoliceShot_i \\ & + \beta_{10} Year_i + \varepsilon_i \end{aligned} \tag{5}$$

As before, the dependent variables are either the number of victims or the number of fatalities. The independent variables are similar to those used in the previous section. We control for *Age, Year* and include the indicator variables for *Minority, School, Workplace, Culture of Honour State, Arrested* and *Shot by Police*. The independent variables of interest in Equation (5) are the indicator variable, *Mental Illness*, for whether there were reported signs of mental illness in the gunman, the indicator variable *Use Depression Med*, for whether the gunman had reportedly been prescribed depression medication, and the indicator variable *Off Depression Med*, for whether the gunman had previously been prescribed depression medication, but was reported off the depression medication at the time of the incident.

Results from estimating Equation (5) using negative binomial regressions are reported in Table 7 along with robust standard errors. As before, in unreported tests we estimate Equation (5) using Poisson regressions and find results to be qualitatively similar to our negative binomial results. Columns 1–3 and 6–8 present the results from simple regressions where we include each independent variable of interest. Columns 5 and 10 report the results from estimating the full model for each dependent variable. Because we are able to draw inferences from the full models that are similar to those from the various simple regressions, we only discuss our findings in columns 5 and 10.

Column 5 shows that after controlling for a variety of other variables both *Mental Illness* and *Use Depression Med* produce estimates that are positive

Table 7. Determining the number of victims and fatalities: effect of mental status.

	Dependent variable: victims					Dependent variable: fatalities				
	1	2	3	4	5	6	7	8	9	10
Mental Illness	0.456***			0.396**	0.312**	0.325**			0.236	0.192
	(0.154)			(0.165)	(0.138)	(0.163)			(0.171)	(0.151)
Use Depression Med		0.518***		0.381**	0.335**		0.645***		0.513***	0.531***
		(0.156)		(0.165)	(0.162)		(0.136)		(0.152)	(0.163)
Off Depression Med			−0.279	−0.230	0.101			−0.933***	−0.833***	−0.448**
			(0.242)	(0.225)	(0.189)			(0.168)	(0.178)	(0.180)
Age					−0.010***					−0.004
					(0.004)					(0.005)
Minority					−0.137					0.032
					(0.138)					(0.162)
School					−0.433*					−0.514**
					(0.231)					(0.239)
Workplace					−0.622***					−0.693***
					(0.165)					(0.141)
Culture of Honour State					0.041					−0.074
					(0.121)					(0.156)
Arrested					−0.190					−0.603***
					(0.136)					(0.151)
Shot by Police					−0.232*					−0.386**
					(0.138)					(0.169)
Year					−0.031***					−0.031***
					(0.008)					(0.007)
Observations	184	184	184	184	184	184	184	184	184	184

Coefficients from negative binomial regressions. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

and significantly differ from zero. These results suggest that differences in the mental health of the gunmen are directly associated with the number of victims in an active shooter event. This finding also states that despite the use of depression medication mental illness still has a direct effect on the number of victims.

Column 10 presents the coefficients when using the number of fatalities as the dependent variable. Here, we do not find that mental health of the gunman is correlated with the number of fatalities. However, we again find that the use of depression medication is associated with a higher number of fatalities. Interestingly, being off of depression medication is associated with a significantly lower number of fatalities. The coefficients for *School, Workplace, Arrested* and *Shot by Police* are again negative and significant at the 0.05 level, which is consistent with our findings in the previous tables. The results in this subsection have some important implications that might also add to the gun policy debate. While Table 2 shows that about 46% of gunmen had signs of mental illness, Tables 5 and 6 present some evidence that mental illness is indeed an important determinant of the number of victims/fatalities. In this last table, we observe that the use of depression medication is also associated with a high number of victims/fatalities. This could mean one of two things. First, the use of depression medication may simply signal that a particular gunman had severe mental health issues, which could explain the higher number of victims/fatalities. Second, our findings might suggest that depression medication is not an important deterrent in the severity of crimes committed by the mentally ill.[16]

IV. Conclusion

After recent active shooter events, policymakers have renewed the debate about how to prevent more of these incidents from occurring. A call for greater regulation has been made by the public as well as by politicians. However, little is known about the factors that impact whether an event occurs and the outcomes of such events. To inform policy, this study takes a comprehensive look at these types of incidents in the United States during the last 31 years. Our analyses find that most gun laws are not correlated with whether an event occurs, with the exception of state assault weapons laws which show a consistent negative correlation. However, neither state nor federal assault weapons laws are significantly related to whether these types of weapons are used in active shooter events.

When taking a closer look at the incidents themselves, our multivariate results show that the use of assault weapons is not generally associated with an increase in the number of victims or the number of fatalities. On the other hand, the uses of high-capacity magazines, handguns and shotguns are all consistently associated with increases in both the number of victims and fatalities. Combined with earlier findings, these results suggest that policymakers might want to focus future policy on other areas besides the regulation of assault weapons.

Our tests also show that signs of mental illness in the gunman are positively correlated with the number of victims and fatalities. In particular, current use of depression medication is significantly correlated with an increase in the number of victims and fatalities. These results indicate that improvements in mental health may reduce the severity of active shooter events.

Disclosure statement

No potential conflict of interest was reported by the authors.

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