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The Relation Between State Gun Laws and the Incidence and Severity of Mass Public Shootings in the United States, 1976–2018

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Objective: In this study, we analyzed the relationship between state firearm laws and the incidence and severity (i.e., number of victims) of mass public shootings in the United States during the period 1976–2018. ***Hypotheses:*** We hypothesized that states requiring permits to purchase firearms would have a lower incidence of mass public shootings than states not requiring permits. We also hypothesized that states banning large-capacity ammunition magazines would experience a lower number of victims in mass public shootings that did occur than states without bans. ***Method:*** We developed a panel of annual, state-specific data on firearm laws and mass public shooting events and victim counts. We used a generalized estimating equations logistic regression to examine the relationship between eight state firearm laws and the likelihood of a mass public shooting. We then used a zero-inflated negative binomial model to assess the relationship between these laws and the number of fatalities and nonfatal injuries in these incidents. ***Results:*** State laws requiring a permit to purchase a firearm were associated with 60% lower odds of a mass public shooting occurring (95% confidence interval [CI: −32%, −76%]). Large-capacity magazine bans were associated with 38% fewer fatalities (95% CI [−12%, −57%]) and 77% fewer nonfatal injuries (95% CI [−43%, −91%]) when a mass shooting occurred. ***Conclusion:*** Laws requiring permits to purchase a gun are associated with a lower incidence of mass public shootings, and bans on large capacity magazines are associated with fewer fatalities and nonfatal injuries when such events do occur.

Public Significance Statement
We cannot definitively conclude that implementing a specific law would lead to a change in the incidence or severity of mass public shootings. However, laws that limit potential shooters' access to firearms by requiring permits may reduce the incidence of mass shootings, and laws that limit the number of shots that can be fired before reloading may reduce the severity of mass public shootings when they do occur. Such laws must be balanced with citizens' right to bear arms under the Second Amendment of the U.S. Constitution.

Keywords: firearms, mass public shootings, homicide, state laws, policy

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The recent occurrence of high-profile mass shootings, such as the tragedies in Parkland (Florida), Las Vegas (Nevada), El Paso (Texas), and Dayton (Ohio), has led to growing frustration and vigorous debate regarding policies intended to prevent these events (Nagin, Koper, & Lum, 2020; Wintemute, 2018). Although mass public shootings are a rare form of violence, there is general agreement—based on combined data from both the supplementary homicide reports and searches of online newspaper databases—that both the incidence and the severity of these events have increased in recent years (Duwe, 2020). Given this increase in morbidity and mortality, and the fear these incidents instill, it has never been more important to identify laws that will help curtail the incidence and/or severity of mass public shootings in the United States. However, there is scant research into the effectiveness of gun laws in preventing mass public shootings or reducing the number of victims in such incidents.

In this study, we analyzed the relationship between state firearm laws and the incidence and severity (i.e., number of victims) of mass public shootings in the United States during the period 1976–2018. We proceed by: (a) presenting the theoretical basis for believing that certain firearm laws may reduce the incidence or severity of mass public shootings; (b) reviewing the existing literature on the effect of state firearm laws on mass shootings; (c) discussing the limitations of the existing research in terms of both the predictor variable (i.e., definition of firearm laws) and outcome variable (quantification of mass shootings); and (d) providing an overview of the present study and how it advances the literature by addressing these limitations.

Conceptual Basis for Hypothesizing a Potential Impact of Specific State Firearm Laws on Mass Shooting Incidence or Severity

We used a theoretical model that was derived from studies of the relationship between gun availability and violent crime (Cook, 1983). This model combines criminological and economic theories to posit that laws that restrict criminals' access to guns deter firearm violence by reducing the availability of guns, both through legal and illicit markets, and therefore increase the effective cost of obtaining a highly lethal weapon. Cook argued that "despite the vast arsenal of guns in private hands, guns remain a scarce commodity. This scarcity surely prevents some criminals from obtaining them or using them in violent crime . . ." (pp. 76–77). This theory suggests not only that limiting the availability of firearms will make it more difficult to purchase a gun legally but that it will also limit the supply of or increase the costs of obtaining guns through illicit markets (Cook, 1983). Detailed study of a sample of mass murderers revealed that specific precipitating events are extraordinarily common (Hempel, Meloy, & Richards, 1999). If a potential perpetrator does not already own a firearm, the cost of obtaining one might be a critical factor in his ability to commit a mass shooting.

At the population level, several studies have documented a relationship between increased access to firearms and higher rates of violent crime, both for access to legal (Miller, Azrael, & Hemenway, 2002; Siegel, Ross, & King, 2013) and illegal firearms (Stolzenberg & D'Alessio, 2000). At the individual level, a recent study demonstrated that neighborhood firearm availability was related to more than a doubling of the odds for the commission of gun violence among adolescents with a previous history of conviction for a felony or a gun-related misdemeanor (Gonzales & McNiel, 2020). A previous study had shown that the availability of guns in the home was a significant risk factor for adolescent gun violence, regardless of whether the youth had a history of gun possession or violent crime (Ruback, Shaffer, & Clark, 2011). Thus, even among offenders with a history of gun-related crime, the availability of guns may be a significant factor in whether they carry out future acts of firearm violence.

This study focused on eight state firearm laws for which there is a conceptual basis for believing that they may impact either the incidence of mass shootings or the number of casualties resulting from such an event by limiting the availability of highly lethal firearms and/or ammunition. Each of these laws, described below, may increase the effective cost of obtaining any firearm, a specific type of firearm (e.g., an assault weapon), or a specific type of ammunition (e.g., high-capacity magazines). The laws either limit access to these weapons by people who are at high risk of violence or restrict the sale of particular types of guns or ammunition.

Assault Weapon Bans

Assault weapons are military-style weapons typically defined as semiautomatic firearms that accept a detachable magazine and have one or more military features such as flash suppressors, bayonet lugs, grenade launchers, pistol grips, and barrel shrouds. A survey of experts in public health, law, and criminology revealed that they ranked bans on assault weapons as an effective strategy to prevent mass shootings (Sanger-Katz & Bui, 2017). The first conceptual basis for the hypothesis that bans on military-style assault weapons may help prevent mass shootings or limit their severity is the finding that assault weapons have been used in a large proportion of such events. Although definitive data are not available, among mass shooting incidents in which weapon information was sufficient, 36% involved the use of an assault weapon (Koper, Johnson, Nichols, Ayers, & Mullins, 2018). The second conceptual basis for an effect of assault weapon bans is the finding that attacks in which the assailant uses a military-style weapon, such as an assault rifle, result in a greater number of shots fired, victims wounded, and severe or multiple wounds (de Jager et al., 2018; Koper, 2020; Reedy & Koper, 2003). Thus, reducing the stock of assault weapons could decrease the likelihood that a shooting incident results in enough fatalities to be classified as a mass shooting (de Jager et al., 2018; Koper, 2020).

Bans on Large-Capacity Ammunition Magazines

The conceptual basis behind restricting the size of ammunition magazines as a strategy to confront mass shootings is that large-capacity magazines "increase the ability to fire large numbers of bullets without having to pause to reload. Any measure that can force a pause in an active shooting—creating opportunities for those in the line of fire to flee, take cover, or physically confront a gunman—offers a possibility of reducing the number of victims in such an attack" (Klarevas, Conner, & Hemenway, 2019, p. 1,761). Nearly 20% of mass shootings during the period 2009–2016 involved weapons with a large-capacity magazine (Koper et al., 2018), whereas two thirds of high-fatality mass shootings (i.e., six or more fatal victims) between 2006 and 2015 involved this

type of magazine (Klarevas, 2016). Restrictions on the size of magazines are conceptually more likely to be effective than banning assault weapons because these weapons are not functionally different from other semiautomatic firearms but are typically equipped with high-capacity magazines (Koper, 2020). Moreover, large-capacity ammunition magazine bans pertain to a much larger number of firearms because there is a sizable class of semiautomatic weapons that are not assault weapons but that accept high-capacity magazines (Koper, 2020).

Extreme-Risk Protection Orders

Also called red flag laws or gun violence restraining orders, these statutes allow law enforcement officers, family members, or both to petition a court for an emergency order to disarm a person who is judged to be a danger to themselves or others following a due-process hearing. The conceptual basis for their potential in averting mass shootings is the finding that nearly four fifths of those who committed mass shootings had either implicitly or explicitly expressed an intent to carry out such an attack (Laqueur & Wintemute, 2020; United States Secret Service National Threat Assessment Center, 2018). Investigators in California have identified at least 21 cases in which an extreme-risk protection order was used to disarm an individual who had been planning a mass shooting (Wintemute et al., 2019).

Limiting Firearm Access for High-Risk Individuals

Nagin et al. (2020) have put forth recommendations for a general approach to curtailing mass shootings. In addition to restricting high-capacity magazines, they recommend policies that restrict firearm access for people who are at a high risk for violence. States have taken a number of approaches to accomplish this.

Permit requirements. One of the most basic approaches is to require a permit or license to purchase or possess a firearm (Webster, McCourt, Crifasi, Booty, & Stuart, 2020). Seven states (e.g., Massachusetts, New Jersey) currently have permit requirements in place.

"May-issue" laws. A related approach is one that allows law enforcement officials discretion in deciding whether or not to approve an application for a concealed carry license. This is called a may-issue law and stands in contrast from shall issue laws that give no discretion to police; unless the applicant has been convicted of a specified offense, jis or her application must be approved. Nine states (e.g., California, Connecticut) currently have may-issue laws in place.

Violent misdemeanor laws. Another approach is to prohibit firearm possession by people who are at the highest risk of violence, namely those who have a history of violence. Federal law prohibits gun possession only by those convicted of a felony or certain misdemeanors (i.e., domestic violence and gun offenses). Some states, however, have enacted violent misdemeanor laws that extend the federal prohibition to include all violent crimes. Four states (e.g., Hawaii, Maryland) currently have violent misdemeanor laws in place.

Relinquishment laws. Approximately 46% of the assailants in mass shootings during the period 2014–2017 were legally prohibited from purchasing or possessing a firearm (Zeoli & Paruk, 2020). This is the rationale behind relinquishment laws that provide for the confiscation of firearms from all individuals who become prohibited from possessing them, even if they initially acquired the gun legally. Seven states (e.g., Illinois, Pennsylvania) currently have relinquishment laws in place.

Universal background checks. Firearm ownership prohibitions may not work unless a state has a system of universal background checks, requiring that every gun purchaser be screened at the point of sale to determine whether they meet any criterion that would disqualify them from gun purchase under federal and/or state law (Webster et al., 2020). Eleven states (e.g., Colorado, Oregon) currently have universal background check laws in place.

Research on the Impact of Firearm Laws on Mass Shootings

The early research in this area focused on assessing the impact of the 1994 federal ban on assault weapons and large-capacity ammunition magazines, yielding inconsistent results (Morral et al., 2018). These studies are difficult to interpret in the absence of a comparison group and therefore limited evidence upon which to identify the counterfactual. More recently, research has focused on studying the effects of state firearm laws, which allows multiple group or panel study designs because there is indeed a wide variation in the adoption of firearm laws across states and across time (Siegel, et al., 2017).

Whereas research remains limited, there is some evidence that more permissive state gun laws are associated with higher rates of mass shootings (Reeping et al., 2019). Reeping et al. (2019) reported that for each 10-unit increase in the permissiveness of state gun laws (measured on a 100-point scale), the rate of mass shootings in a state increased by 11.5%. However, this study did not examine the impact of any specific firearm laws. In addition, it relied on a travel guide to assess state laws and did not independently verify the validity of the database. Also, in contrast, Lin, Fei, Barzman, and Hossain (2018) failed to find a statistically significant relationship between the permissiveness of state gun laws and the rate of mass shootings, although it is not clear what laws were included in their gun law index.

In 2015, Gius (2015) reported the results of the first study to examine the impact of state laws on mass shootings. He found that during the period 1982–2011, state-level assault weapons bans were associated with a significantly lower number of fatalities in mass shootings. In a more recent state-level study using a panel design, Klarevas et al. (2019) investigated the relationship between the incidence and number of deaths in high-fatality mass shootings (those with at least six fatalities, not including the perpetrator) and state-level large-capacity magazine bans. They found that these policies were associated with a significantly lower incidence of these mass shooting events and with a significantly lower death count. Unfortunately, this study considered the impact of only one type of firearm law and by virtue of the high-victim threshold was based on a particularly small number of cases.

Most recently, Webster et al. (2020) advanced the literature by examining the impact of a number of specific state laws on the incidence of fatal mass shootings from 1984 through 2017. They found that two laws—required licenses for handgun purchase and large-capacity magazine bans—were associated with fewer mass

shootings. Additionally, required licenses reduced the number of fatalities in mass shootings.

Limitations of the Predictor Variable in Existing Research: Classification of State Firearm Laws

The primary limitation of the previous studies in terms of their classification of state firearm laws is that none of them provide clearly defined criteria to determine what counts as having a particular law and what does not. State firearm laws often have various exemptions, exceptions, and differences in application of restrictions. Without a clear definition of what is meant by a particular law, there is ambiguity in how that law should be coded (Siegel, et al., 2017). Thus, for any particular study, it is not precisely clear what is meant by the presence or absence of a particular law.

For example, Gius (2015) classified Hawaii as having enacted an assault weapons ban in 1992. However, Hawaii's statute restricts only the sale of assault pistols; the law does not apply to assault rifles. Without having clearly defined the meaning of an assault weapons ban, most readers would probably assume that assault rifles are banned in Hawaii, but that is not the case (Hawaii Revised Statutes, 2020). This law would not be expected to affect the incidence or severity of mass shootings, but it is included in the treatment group in the study. Similarly, Klarevas et al. (2019) classified Hawaii as having a ban on large-capacity magazines. However, this ban applies only to detachable magazines for pistols. There is no limit to the magazine capacity for rifle ammunition (Hawaii Revised Statutes, 2020).

Reeping et al. (2019) obtained their state firearm law data from the *Traveler's Guide to the Firearms Laws of the Fifty States*. The book focuses almost exclusively on laws governing where one can carry a concealed firearm. Thus, the gun permissiveness scale is relevant only to one small subset of firearm laws. Lin et al. (2018) do not even describe how they derived their gun law permissiveness index, although it appears that it may have been solely based on the state's concealed carry permitting law.

Limitations of the Outcome Variable in Existing Research: Methods Used to Quantify Mass Shootings

Most of the existing research is limited because it relies on one of two sources to quantify mass shootings: (a) the Federal Bureau of Investigation (FBI)'s Supplementary Homicide Reports; or (b) news coverage (Duwe, 2020). Each of these approaches to identify mass shootings has serious flaws.

Studies relying on the Supplementary Homicide Reports. At least three studies used the FBI's Supplementary Homicide Reports (SHR) as the main basis of their analyses, identifying those incidents in which four or more victims are fatally shot (Gius, 2015; Reeping et al., 2019; Webster et al., 2020). In addition to its limited range of variables, the SHR unfortunately presents a number of pitfalls for analytic efforts of this sort. There are situations in which separate and unrelated homicides are reported by a law enforcement agency on the same record giving the false appearance of a mass killing. In addition, occasionally a record will include an injured victim along with three fatalities also wrongly suggesting a mass killing. On the other hand, there are many mass shootings that for various reasons are omitted from the SHR. Some states are excluded from the SHR entirely for certain years because of issues with their data collection or reporting, and some jurisdictions fail to report all their homicides to the FBI (Fox, 2004).

Beyond these validity concerns, one must approach the SHR carefully with respect to particularly large-scale shootings. Because each data record is limited to 11 victims, certain mass shootings necessarily span several records, falsely suggesting multiple events. In Reeping et al.'s (2019) data, for example, Virginia is recorded as having 13 mass shootings when in fact several of these are just additional records needed to cover all the victims killed at Virginia Tech in 2007. At least one study indicated that the accuracy rate of the SHR in identifying mass shootings is only 61% (Overberg, Upton, & Hoyer, 2013).

Studies relying on media reports. Two studies relied on news reports compiled by *Mother Jones* (Gius, 2015; Lin et al., 2018). One combined data from *Mother Jones* with information from the SHR (Gius, 2015), whereas the other relied on *Mother Jones* as the sole data source (Lin et al., 2018). The *Mother Jones* list of mass shootings missed more than 40% of the incidents that occurred during the period 1982–2013, and its underreporting was particularly severe for the earlier 2 decades (Duwe, 2020). Although most mass shootings receive media attention, many are covered only in local media (Duwe, 2020). Moreover, accuracy is dependent on the extensiveness of media outlet coverage by a news media database and by the precise search terms used (Duwe, 2020). For example, a search for the term mass shooting will miss incidents described by a reporter as a quadruple shooting (Duwe, 2020). In addition, because the term mass shooting is relatively new, searches relying only on that phrase will likely undercount incidents from before the 2000s (Duwe, 2020).

Study Overview and Hypotheses

In this study, we took advantage of two new databases to further the existing research on the association between state firearm laws and mass public shootings by addressing limitations in both the predictor and outcome variables. First, we used a novel database that coded the status of 89 different state gun laws from 1976 to the present, using clearly defined criteria for identifying each law. Second, we used a comprehensive database of mass public shooting incidents from 1976 through 2018 assembled by combining all existing mass shooting databases and extensively evaluating each identified case. This triangulated data collection strategy incorporated information from the SHR, from existing databases that utilized news media reports, and from original searches of the entire database of news stories at multiple media resource websites. Institutional review board approval was not needed for this study because the data were obtained from secondary, publicly available sources.

Mass shootings have typically been defined as events in which four or more victims are fatally shot during a short period of time (Duwe, 2020). Whereas the public tends to envision mass shootings as incidents in which a shooter indiscriminately fires into a crowd of people in a public place, prior research indicates the majority of mass murders—about 70%—are actually familicides or felony-related killings, which are types of events less likely to be covered by the media (Duwe, 2020). The term, mass public shootings, is used to connote the former incidents: gun-related

incidents in which strangers are killed in a public location absent other criminal activity (Duwe, 2020).

There are a few reasons that, in this paper, we focused exclusively on mass public shootings. Studies have previously examined the relationship between gun laws and shooting events with at least four fatalities, regardless of where the shooting took place. A large number of these mass shootings are domestic incidents involving the killing of family members that may have occurred in a private home rather than in a public place, as was the case with the Reeping et al. (2019) and Webster et al. (2020) studies. A second large subset of these mass shootings consists of those committed as part of an underlying criminal activity in which the killing is not the primary intended purpose but is necessary or becomes necessary to carry out the planned crime. Although hardly unimportant, these are not the types of events that typically receive widespread media coverage and may not be consistent with the public's and policymakers' conception of a mass shooting. They are also not the shootings that drive the campaign for stronger gun-control legislation (Duwe, 2020).

Our two major hypotheses were as follows: (a) States requiring permits to purchase firearms will have a lower incidence of mass public shootings than states not requiring permits and (b) states that ban large-capacity ammunition magazines will experience a lower number of victims in mass public shootings that do occur than states without bans.

Method

Data Sources

To examine the association between state-level gun laws and the incidence and severity of mass public shootings from 1976 to 2018, we relied on two primary data sets. The first includes a recently developed comprehensive list of mass public shootings using strict definitional criteria, and the second includes a comprehensive list of state laws from a publicly available dataset on all 50 states starting in 1991 that we extended back to 1976.

Mass public shootings. We assembled a database of mass public shootings using a variety of sources to capture all possible events and then researching each in detail to identify those that met our predetermined definition of a mass public shooting. Specifically, we defined a mass public shooting as an incident in which four or more victims are fatally shot in a public location within a 24-hr period in the absence of other criminal activity, such as robberies, drug deals, and gang conflict.

The process by which we collected data on mass public shootings consisted of three main phases. First, the vast majority of the cases in our sample were derived from the data set compiled by Duwe (2020), who used both the SHR and news reports as data sources. Despite its limitations, the SHR is still the most comprehensive source of U.S. homicide data that contain information on the year and month when murders occurred as well as the state and city (or county) where they took place. After relying on the SHR to identify when and where gun-related mass murders occurred in the United States, Duwe searched online newspaper databases to collect additional information not included in the SHR, such as the number of injured victims and the specific location in which the incident took place. As a result of using this triangulated data collection strategy, which was also adopted by *U.S.A. Today* (Overberg et al., 2013) and the Congressional Research Service (Krause & Richardson, 2015), Duwe was able to correct errors in the SHR data while also identifying cases that were either not reported to the SHR or were unlikely to be captured through sole reliance on news coverage.

Second, to help ensure inclusion of every mass public shooting that occurred in the United States between 1976 and 2018, we also consulted unpublished data sets (Brot, 2016; Krause and Richardson, 2015) as well as publicly available ones such as those published by Louis Klarevas (Klarevas et al., 2019); *U.S.A. Today* (2018); *Washington Post* (Berkowitz & Alcantara, 2019); Stanford University (2020); Mother Jones (2020); Everytown for Gun Safety (2020); and FBI active-shooter events (Federal Bureau of Investigation, 2020).

Finally, we conducted a consensus review to determine whether cases qualified as a mass public shooting by our operational definition. More specifically, three of the authors for this study reviewed whether the cases identified through the first two phases met the following criteria: (a) at least four of all victims were killed by gunfire; (b) at least four of the victims were killed in a public place or else at least half of all fatalities occurred in a public place; and (c) the shooting did not occur in a private residence, although those that occurred in a nonprivate residence (e.g., group home or motel) were retained. If all three authors agreed these criteria had been satisfied, the incident was included in this study as a mass public shooting. If there was any disagreement, the coders discussed the case until they reached agreement on the classification.

For each case, the coders classified the incident as yes, no, or maybe. Of the 188 possible cases identified, all three coders agreed on the classification being yes or being no for 175 of the cases (93.1%). In an additional three cases, two coders agreed on the classification and the third was not sure. There was disagreement or uncertainty for 10 cases. The interrater reliability was assessed using an extension of Cohen's kappa for more than two raters (Stata Base Reference Manual, 2017). Cohen's kappa was 0.82, which indicates very good agreement between coders (Altman, 1999).

As a result of this rigorous data-collection methodology, we assembled a comprehensive database, consisting of 156 mass public shootings from 1976 through 2018 that involved 2,839 victims, of which 1,090 were fatally shot, another 41 died by other means, and the remaining 1,708 were injured. We omitted one incident, the fatal shooting of 12 victims in Washington, DC, from the analyses, given the focus on the laws enacted by the 50 states, leaving the final counts of 155 incidents and 2,827 victims for this study. We developed a panel by calculating the number of events, killings, and nonfatal shootings by year and state. With data for 50 states across 43 years, the panel consisted of 2,150 observations in total.

State firearm laws. We relied on the State Firearm Law Database, a publicly available database of the presence or absence of 134 state firearm law provisions across 14 categories in all 50 states for the period 1991 to the present that was developed by individual examination of state statutes and historical session laws with detailed criteria defining each provision (Siegel, 2020a, 2020b; Siegel, et al., 2017). For 89 of these law provisions, we extended the database back to 1976 by examination of historical state statutes and session laws using the Hein Online and Westlaw

Edge databases. We focused on these 89 provisions because they represent the policies most commonly considered by state lawmakers to reduce intentional firearm violence (Morral et al., 2018). The provisions we excluded from the extended database were either minor policies or those designed to reduce unintentional injuries or to help identify offenders once crimes have already been committed. For example, we excluded laws such as record-keeping requirements for gun stores, ballistic fingerprinting of guns, gun storage liability laws, and personalized gun technology.

Measures

Predictor variables. From the expanded state firearm law database, we selected eight specific laws for analysis based on two criteria: (a) laws that were analyzed in previous studies of mass shootings and (b) laws for which we could identify published literature providing a conceptual basis to believe they may be effective in averting mass shootings or reducing casualties in such events. The laws were: (a) assault weapons bans; (b) large-capacity magazine bans; (c) laws requiring a permit to purchase or possess a gun; (d) extreme-risk protection order laws; (e) universal background checks; (f) may-issue concealed-carry laws; (g) relinquishment of guns required when people become disqualified from ownership; and (h) laws prohibiting gun possession by people with a history of a violent misdemeanor crime. Online Supplemental Table A displays the laws analyzed, their definitions, and the states that had these laws in effect in 2018. Laws were lagged by 1 year in the analysis; that is, we considered the potential effect of a law only in the full first year after its enactment.

Outcome variables. There were three major outcome variables that measured the incidence and severity of mass public shootings.

Incidence of mass public shootings. Because this outcome variable was dichotomous (the presence or absence of a mass public shooting in a given state during a given year), we used a logistic regression model for this analysis. To account for clustering by state, we used a generalized estimating equations (GEE) approach with an exchangeable working correlation matrix. We included both linear and quadratic trend variables. We generated standard errors that accounted for state clustering and were robust to the correlation structure assumptions (White, 1980). There were a few cases in which a state experienced more than one event in the same year (e.g., California experienced three mass public shootings in 1993). However, these were so few that modifying the outcome variable was not warranted.

Number of fatalities per shooting event. Because of the small number of events, our data set contained a great majority of zero counts (2,007 of 2,150 observations). For this reason, we used a zero-inflated negative binomial model (Yau, Wang, & Lee, 2003). In this approach, we modeled the likelihood of an event occurring separately from the number of fatalities assuming that an event did occur. We used logistic regression to model the likelihood of an event and negative binomial regression to model the number of fatalities when an event did occur. As above, we included linear and quadratic time trends and generated cluster robust standard errors.

One advantage of the zero-inflated model is that the factors associated with event occurrence and with the number of victims given that an event took place can be analyzed separately and with different predictor variables. For the logistic regression of event occurrence, we used all of the same control variables specified above. However, we did not anticipate that these demographic variables would influence the fatal victim count, assuming that an event occurs. For example, the divorce rate might impact the likelihood of a mass shooting, but there is no conceptual reason to believe that the divorce rate influences the number of fatalities resulting from a shooting. Therefore, the only predictors used for the count part of the model were the time trends (included to capture secular trends in the severity of mass public shootings), population, population density, and the state laws, which were the variables of interest.

As a sensitivity analysis, we performed negative binomial GEE regressions on the number of deaths per event using the same limited set of regressors but restricting the analysis to observations when an event occurred ($N = 143$). In this way, the model assessed the relationship between state laws and the number of fatalities in a mass shooting event, independent of any association between these laws and the likelihood of an event occurring in the first place.

Number of nonfatal injuries per shooting event. We conducted a post hoc analysis to investigate whether large-capacity magazine bans are associated with the number of nonfatal injuries when an event occurs. To do this, we performed a zero-inflated negative binomial regression but used only the time trends, population, population density, and large-capacity magazine ban laws to predict the number of injuries per event. Finally, we executed a sensitivity analysis, repeating the above model specification using a negative binomial regression restricted to observations in which an event occurred.

Control variables. We compiled an annual, state-specific panel of data on variables that might be related to both mass shooting rates and the adoption of firearm laws, therefore confounding the results. Because of the limited literature on predictors of mass shooting incidence and severity at the state level, we selected control variables based on their demonstrated association with state rates of overall firearm violence in previous studies. The variables included and the studies documenting their association with firearm violence at the state level were: (a) state population (Knopov et al., 2019; Siegel & Boine, 2019); (b) population density (Knopov et al., 2019; Siegel, Pahn, Xuan, Fleegler, & Hemenway, 2019); (c) proportion identified as Black (Campbell, Siegel, Shareef, & Rothman, 2019; Siegel et al., 2020); (d) proportion of males among young adults (ages 15–29 years) (Knopov et al., 2019; Siegel, Pahn, et al., 2019); (e) poverty rate (Powell & Tanz, 1999; Siegel, Pahn, et al., 2019); (f) unemployment rate (Campbell et al., 2019; Siegel, Pahn, et al., 2019); (g) per-capita alcohol consumption (Siegel, Pahn, et al., 2019, Siegel et al., 2020); (h) divorce rate (Díez et al., 2017); (i) incarceration rate (Campbell et al., 2019; Siegel et al., 2013); (j) household gun ownership (Campbell et al., 2019), using a commonly used proxy: the proportion of suicides committed with a firearm (Azrael, Cook, & Miller, 2004); and (k) the violent crime rate (Campbell et al., 2019; Siegel, Pahn, et al., 2019). We also included the firearm homicide rate and the suicide rate because these are direct measures of the overall magnitude of firearm violence in a state. We linearly interpolated missing years of data. Online Supplemental Table B shows the variables, definitions, data sources, and years with missing data.

Multicollinearity assessment. A unique contribution of this study is its ability to examine a wide range of firearm laws and to isolate the independent effect of laws by controlling for the presence of the others. A potential drawback of this approach is the possibility of multicollinearity. We assessed the potential for high multicollinearity and thus inflated standard error terms by computing variance inflation factors.

We estimated all models using Stata/SE version 15 (StataCorp, College Station, TX). Online Supplemental Table C provides the command syntax for the analyses. The data set, methods, and code used in this research are available online at https://osf.io/mucsh/.

Results

Descriptive Findings

During the period 1976–2018, there were a total of 155 mass public shootings resulting in 1,078 deaths and an additional 1,694 nonfatal injuries in the United States, excluding one event that occurred in nation's capital because it does not fall under the jurisdiction of any state (see Table 1, Figure 1, and Figure 2). The average mass public shooting rate ranged from a high of 0.1963 per million population in Idaho to a low of zero in nine states (see Table 1). California had the greatest number of events (25) and deaths (164), whereas Nevada had the greatest number of overall victims (915) as a result of the massive shooting in Las Vegas in 2017. The number of mass public shootings remained stable or slightly elevated between 1976 and 2002, but there was a sharp increase from 2002 through 2018 (see Figure 1). The number of mass shootings waned during the period 2013–2016 but rose sharply in 2017 and 2018. The trend in deaths followed a similar pattern (see Figure 2).

State Firearm Laws and the Likelihood of a Mass Public Shooting

In the logistic regression GEE model, one law—permit requirements—was associated with 60% lower odds of a mass public shooting (95% confidence interval [CI: −32%, −76%]) as shown in Table 2. No other laws were related to the likelihood of a mass public shooting. Other factors associated with the occurrence of a mass public shooting were population, unemployment rate, divorce rate, firearm homicide rate, and suicide rate.

In the logistic regression portion of the zero-inflated negative binomial model, one law—permit requirements—was associated with 59% lower odds of a mass public shooting (95% CI [−31%, −76%]) as displayed in Table 3. Other factors related to the likelihood of a mass public shooting were population, divorce rate, firearm homicide rate, and suicide rate. These results were consistent with that of the logistic regression.

State Firearm Laws and the Number of Fatalities in a Mass Public Shooting

In the count part of the zero-inflated negative binomial model, one law—large-capacity magazine bans—was associated with fewer deaths when a mass public shooting occurred (see Table 3). A large-capacity magazine ban was associated with 38% fewer fatalities (95% CI [−12%, −57%]). No other laws were significantly associated with a lower number of deaths in a mass public shooting.

In the sensitivity analysis in which we modeled the number of fatalities resulting from mass public shootings using a GEE negative binomial model restricted to only those observations for which an event occurred, large-capacity magazine bans were associated with 37% fewer fatalities (95% CI [−10%, −57%]), as shown in Table 4. No other laws were significantly associated with a lower number of deaths in a mass public shooting. These results

Table 1
Average Mass Public Shooting Rate and Total Number of Events and Deaths—By State, 1976–2018

State	Average rate	Events	Deaths	Nonfatal injuries	Total victims
Alaska	0.1963	4	25	2	27
Idaho	0.0405	2	8	1	9
Mississippi	0.0331	4	20	11	31
Oregon	0.0309	4	23	55	78
Nevada	0.0283	3	66	849	915
Colorado	0.0265	5	37	104	141
Washington	0.0249	7	34	33	67
Rhode Island	0.0244	1	4	0	4
Kentucky	0.0243	4	22	18	40
Connecticut	0.0199	3	39	4	43
New Hampshire	0.0196	1	4	4	8
Hawaii	0.0192	1	7	0	7
Arkansas	0.0189	2	9	13	22
Texas	0.0189	16	134	128	262
Florida	0.0182	12	123	101	224
California	0.0175	25	164	161	325
Wisconsin	0.0165	4	23	9	32
Pennsylvania	0.0132	7	37	15	52
Nebraska	0.0130	1	8	4	12
Missouri	0.0124	3	14	3	17
North Carolina	0.0118	4	20	15	35
South Carolina	0.0108	2	13	4	17
Louisiana	0.0106	2	9	5	14
Georgia	0.0102	4	21	15	36
New York	0.0099	8	46	34	80
Utah	0.0090	1	5	4	9
Minnesota	0.0089	2	15	7	22
Kansas	0.0085	1	5	2	7
Iowa	0.0083	1	5	1	6
Maryland	0.0080	2	9	2	11
Illinois	0.0076	4	19	27	46
Michigan	0.0071	3	14	10	24
Oklahoma	0.0071	1	14	6	20
Tennessee	0.0070	2	9	6	15
Arizona	0.0068	2	12	14	26
Alabama	0.0052	1	4	1	5
Ohio	0.0042	2	8	7	15
Indiana	0.0038	1	4	2	6
Massachusetts	0.0037	1	7	0	7
New Jersey	0.0032	1	6	0	6
Virginia	0.0030	1	32	17	49
Delaware	0	0	0	0	0
Maine	0	0	0	0	0
Montana	0	0	0	0	0
New Mexico	0	0	0	0	0
North Dakota	0	0	0	0	0
South Dakota	0	0	0	0	0
Vermont	0	0	0	0	0
West Virginia	0	0	0	0	0
Wyoming	0	0	0	0	0
All states	0.0129	155	1,078	1,694	2,772

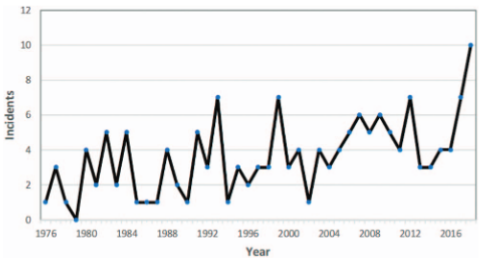

Figure 1. Number of mass public shootings by year—United States, 1976–2018. See the online article for the color version of this figure.

were almost identical to those from the zero-inflated negative binomial model.

Large-Capacity Magazine Bans and the Number of Nonfatal Injuries in a Mass Public Shooting

Large-capacity magazine bans were associated with 77% fewer nonfatal injuries (95% CI [−43%, −91%]), as shown in Table 5. In the sensitivity analysis in which we modeled the number of fatalities resulting from mass public shootings using a GEE negative binomial model restricted to only those observations for which an event occurred, large-capacity magazine bans were associated with 70% fewer nonfatal injuries (95% CI [−29%, −87%]), also shown in Table 5.

Multicollinearity Assessment

Whether we included all regressors or just those pertaining to guns, none of the gun law variables revealed a variance inflation factor above four, a conventional benchmark for concern.

Discussion

To our knowledge, this is the first paper to examine state firearm laws and their separate relationship with the likelihood of a mass public shooting and with the number of fatalities when such an event occurs. We found a robust relationship between state laws that require permits for the purchase and/or possession of guns and the incidence of mass public shootings and between large-capacity magazine bans and the number of deaths resulting from a mass public shooting if one does occur. However, we did not find any significant association between assault weapons bans or other firearm laws and either of these outcomes. Additionally, we found that large-capacity magazine bans are also associated with a lower number of nonfatal injuries when a mass public shooting occurs.

Incidence of Mass Public Shootings

Our finding that laws requiring permits to purchase or possess firearms are associated with a lower incidence of mass public shootings is consistent with those of Webster et al. (2020), who reported that laws requiring handgun permits were associated with a lower number of mass shooting incidents. This supports the theoretical framework that we adapted from Cook (1983), which posits that limiting the availability of firearms may reduce the incidence of mass public shootings by increasing the costs of obtaining a gun in both the legal and illegal markets and that this increased cost could be enough to deter a potential mass shooter. State gun permit requirements have been shown to decrease firearm homicide rates (Crifasi et al., 2018; Webster, Crifasi, & Vernick, 2014) and to reduce straw purchasing or trafficking of guns that diverts them into the illegal market (Collins et al., 2018; Crifasi, Buggs, Choksy, & Webster, 2017).

Similar to Webster et al. (2020), we did not find that universal background check laws are related to the likelihood of mass public shootings. Background checks are typically conducted through the FBI National Instant Criminal Background Check System, which consults only national databases. State mental health, drug use, and criminal databases are not searched, and several studies have documented severe limitations of state reporting to the National Instant Criminal Background Check System database (Goggins & Gallegos, 2016; Mayors Against Illegal Guns, 2011). In contrast to the federal background check system, states that require their own gun permits typically have detailed procedures that involve a check of multiple state databases and often require fingerprints rather than relying solely on self-reported information (Webster et al., 2020). Also, states that conduct their own background checks or delegate this responsibility to local authorities have lower firearm homicide rates than states that rely solely on federal background checks (Sumner, Layde, & Guse, 2008). Requiring permits to purchase or possess firearms is an effective mechanism for conducting effective criminal background checks at the local level.

Severity of Mass Shootings

Our finding that state laws prohibiting large-capacity ammunition magazines are associated with fewer fatalities and nonfatal injuries in mass public shootings is consistent with that of Klarevas et al. (2019), who reported that state-level large-capacity magazine bans were associated with a reduction in the number of deaths in high-fatality (six or more victims shot to death) mass shootings and that of Webster et al. (2020), who observed that laws banning large-capacity magazines were associated with a lower number of deaths from mass shootings. It is plausible that a ban on large-capacity magazines would not stop mass shootings per se but could

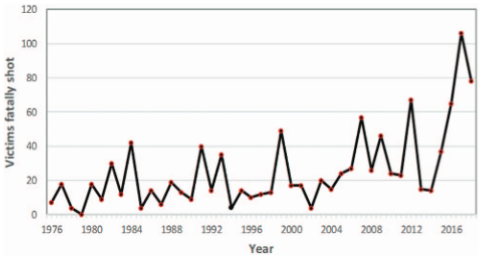

Figure 2. Number of deaths from mass public shootings by year—United States, 1976–2018. See the online article for the color version of this figure.

Table 2
Logistic Regression Model Results: Factors Affecting Occurrence of a Mass Public Shooting, 1976–2018[a]

Factor	*OR* [95% CI]	Statistical significance
Population (in millions)	**1.11**[b] **[.09, 1.14]**	$p < .001$
Population density (in people per .01 square miles)	0.96 [0.84, 1.08]	$p = .47$
Percent Black	0.97 [0.93, 1.02]	$p = .23$
Percent male of young adults	1.22 [0.93, 1.61]	$p = .15$
Poverty rate	0.98 [0.92, 1.05]	$p = .57$
Unemployment rate	**1.10**[b] **[1.00, 1.22]**	$p = .05$
Per-capita alcohol consumption	1.45 [0.93, 2.26]	$p = .10$
Divorce rate	**1.15**[b] **[1.00, 1.32]**	$p = .05$
Incarceration rate (per 1,000 population)	0.99 [0.83, 1.18]	$p = .93$
Household gun ownership	1.00 [0.96, 1.04]	$p = .93$
Age-adjusted firearm homicide rate	**1.20**[b] **[1.02, 1.41]**	$p = .03$
Age-adjusted total suicide rate	**0.85**[b] **[0.74, 0.98]**	$p = .02$
Violent crime rate	0.96 [0.82, 1.12]	$p = .59$
Assault weapons ban	1.36 [0.38, 4.86]	$p = .64$
Large-capacity ammunition magazine ban	0.44 [0.13, 1.44]	$p = .18$
Permit requirement	**0.40**[b] **[0.24, 0.68]**	$p = .001$
Extreme-risk protection order law	1.08 [0.22, 5.19]	$p = .93$
Universal background checks at point of sale	0.51 [0.18, 1.43]	$p = .20$
May-issue concealed-carry law	1.26 [0.76, 2.08]	$p = .37$
Relinquishment law	1.05 [0.52, 2.11]	$p = .90$
Violent misdemeanor law	0.64 [0.23, 1.79]	$p = .40$

Note. *OR* = odds ratio; CI = confidence interval.
[a] Outcome variable is whether or not a mass public shooting occurred in a given state in a given year. State clustering was accounted for using generalized estimating equations. All models include linear and quadratic trends. Standard errors are robust and adjusted for state-level clustering. [b] Coefficient is statistically significant from zero ($p < .05$), also shown in bold type.

at least reduce the number of fatalities and nonfatal injuries in such events because the shooter can fire fewer rounds before having to reload (Klarevas et al., 2019; Koper, 2020; Webster et al., 2020). This is consistent with a body of literature demonstrating that fatality counts in mass shootings are higher when a large-capacity magazine is used by an assailant (Koper, 2020; Koper et al., 2018).

In contrast to high-capacity magazine bans, we did not find support for the often-claimed association between assault weapon bans and mass public shootings. This conflicts with Gius' (2015) contention but is in accord with that of Webster et al. (2020). Our failure to identify an association of assault weapons bans and the incidence of, or fatalities in, mass public shootings could be explained by the fact that assault weapons are typically defined by cosmetic features rather than characteristics that directly affect the lethality of the firearm (Siegel & Boine, 2019) or by the relative infrequency of assault weapon use in mass public shootings (Duwe, 2007). Most semiautomatic firearms are not assault weapons as defined by state laws but are functionally equivalent. They are manufactured without the accessories, such as bayonet lugs, flash suppressors, and grenade launchers, that characterize assault weapons. Moreover, the firing rate of all semiautomatic weapons is the same, regardless of whether they are military-style assault weapons or just handguns, namely the speed at which the shooter can squeeze the trigger. What makes assault weapons so lethal is not any particular functional feature but simply the fact that these firearms are designed to accommodate high-capacity magazines. This may explain our finding that large-capacity magazine bans, but not assault weapon bans, were related to the number of casualties in mass public shootings.

Our finding that only two policies—permit requirements and large capacity magazine bans—were related to mass public shootings is consistent with that of Webster et al. (2020), who reported a similar result. Like Webster et al. (2020), we failed to find a relation between may-issue laws or violent misdemeanor laws and mass public shootings. Because may-issue laws affect only the ability to carry a concealed gun not the ability to purchase a firearm, one might not expect these policies to affect mass public shootings. Violent misdemeanor laws are designed to prevent adjudicated violent criminals from possessing firearms; however, in a substantial proportion of mass shootings, there is no history of a criminal conviction for a violent crime or the crime involves domestic violence (Hempel et al., 1999). Studies have documented serious loopholes in the confiscation of firearms from domestic violence offenders (Mascia, 2015). Strengthening the procedures for the surrender of firearms by persons adjudicated for domestic violence or served with restraining orders may be necessary to observe a measurable effect of these policies on rare mass public shooting events. Similarly, our failure to find a relationship between relinquishment laws and mass public shootings could have more to do with the lack of enforcement of these laws than with a conceptual problem with the idea of limiting potential shootings by making sure that people who become prohibited from possessing a firearm are disarmed.

Perhaps the most surprising negative finding was that extreme-risk protection orders were not related to the incidence of mass public shootings. However, our definition of extreme-protection order laws included those in which law enforcement personnel are authorized to initiate a proceeding, regardless of whether family

Table 3
Zero-Inflated Negative Binomial Model Results: Factors Affecting Occurrence of a Mass Public Shooting and Number of Deaths if a Mass Shooting Occurs, 1976–2018[a]

Factor	Logistic model		Negative binomial model	
	OR [95% CI]	Statistical significance	Incidence rate ratio [95% CI]	Statistical significance
State population (in millions)	**1.11**[b] **[1.09, 1.14]**	$p < .001$	1.01 [1.00, 1.03]	$p = .07$
Population density (per .01 square miles)	0.96 [0.85, 1.08]	$p = .49$	0.99 [0.91, 1.09]	$p = .90$
Percentage Black	0.97 [0.93, 1.02]	$p = .23$		
Percentage male (of young adults)	1.22 [0.93, 1.61]	$p = .15$		
Poverty rate	0.98 [0.92, 1.05]	$p = .57$		
Unemployment rate	1.10 [1.00, 1.22]	$p = .05$		
Per-capita alcohol consumption	1.45 [0.93, 2.26]	$p = .10$		
Divorce rate	**1.15**[b] **[1.00, 1.33]**	$p = .05$		
Incarceration rate (per 1,000 population)	0.99 [0.83, 1.19]	$p = .94$		
Household gun ownership	1.00 [0.96, 1.04]	$p = .93$		
Age-adjusted firearm homicide rate	**1.20**[b] **[1.02, 1.42]**	$p = .03$		
Age-adjusted total suicide rate	**0.85**[b] **[0.75, 0.98]**	$p = .03$		
Violent crime rate	0.96 [0.82, 1.12]	$p = .57$		
Assault weapons ban	1.36 [0.36, 5.11]	$p = .65$	1.04 [0.57, 1.90]	$p = .89$
Large-capacity ammunition magazine ban	0.45 [0.13, 1.55]	$p = .21$	**0.62**[b] **[0.43, 0.88]**	$p = .008$
Permit requirement	**0.41**[b] **[0.24, 0.69]**	$p = .001$	0.80 [0.50, 1.30]	$p = .37$
Extreme-risk protection order law	1.04 [0.21, 5.07]	$p = .96$	1.55 [0.65, 3.69]	$p = .32$
Universal background checks at point of sale	0.51 [0.17, 1.53]	$p = .23$	0.83 [0.41, 1.68]	$p = .61$
May-issue concealed-carry law	1.23 [0.74, 2.04]	$p = .42$	1.21 [0.90, 1.63]	$p = .20$
Relinquishment law	1.04 [0.51, 2.14]	$p = .91$	1.13 [0.47, 2.69]	$p = .79$
Violent misdemeanor law	0.67 [0.24, 1.88]	$p = .45$	0.80 [0.37, 1.74]	$p = .58$

Note. *OR* = odds ratio; CI = confidence interval.
[a] Models include linear and quadratic trends. Standard errors are robust and adjusted for state-level clustering. [b] Coefficient is statistically significant from zero ($p < .05$), also shown in bold type.

members can do so. We could not examine extreme-risk protection order laws that allow family members to intervene because only two states had such laws in place for more than 1 year during the study period. It may be that family members are in the best position to recognize people with access to guns who are at great risk of harming others or themselves. If this were the case, it could explain our failure to find any significant association between mass public shootings and laws that rely on law enforcement officials to identify at-risk individuals.

Policy and Research Implications

Because of the cross-sectional nature of this study, we cannot definitively conclude that implementing a specific law would lead to a change in the incidence or severity of mass public shootings. Nevertheless, our research suggests three potential policy implications that must be balanced with citizens' right to bear arms under the Second Amendment of the U.S. Constitution. First, to reduce the incidence of mass shootings, the primary objective

Table 4
Negative Binomial GEE Model Results: Factors Affecting the Number of Fatalities in a Mass Public Shooting, 1976–2018[a]

Factor	Negative binomial model incidence rate ratio [95% CI]	Statistical significance
State population (in millions)	**1.01**[b] **[1.00, 1.03]**	$p = .03$
Population density (per .01 square miles)	1.00 [0.92, 1.08]	$p = .92$
Assault weapons ban	1.08 [0.63, 1.85]	$p = .78$
Large capacity ammunition magazine ban	**0.63**[b] **[0.43, 0.90]**	$p = .01$
Permit requirement	0.83 [0.54, 1.29]	$p = .41$
Extreme-risk protection order law	1.65 [0.74, 3.70]	$p = .22$
Universal background checks at point of sale	0.79 [0.45, 1.38]	$p = .41$
May-issue concealed-carry law	1.15 [0.88, 1.52]	$p = .31$
Relinquishment law	1.07 [0.53, 2.15]	$p = .85$
Violent misdemeanor law	0.86 [0.44, 1.69]	$p = .66$

Note. CI = confidence interval; GEE = generalized estimating equations.
[a] This model is restricted to observations when a mass shooting event occurred. It includes linear and quadratic trends. Standard errors are robust and adjusted for state-level clustering. [b] Coefficient is statistically significant from zero ($p < .05$), also shown in bold type.

Table 5
Zero-Inflated Negative Binomial Model and Negative Binomial GEE Model Results: Factors Affecting the Number of Nonfatal Injuries in a Mass Public Shooting if a Mass Shooting Occurs, 1976–2018[a]

Factor	Incidence rate ratio [95% CI] [statistical significance]	
	Zero-inflated negative binomial model	Negative binomial GEE model
State population (in millions)	**1.04**[b] **[1.01, 1.06]** [$p = .001$]	**1.02 [1.02, 1.06]** [$p = .32$]
Population density (per .01 square miles)	**0.65**[b] **[0.62, 0.85]** [$p < .001$]	**0.70**[b] **[0.53, 0.92]** [$p = .01$]
Large-capacity ammunition magazine ban	**0.23**[b] **[0.09, 0.57]** [$p = .002$]	**0.30**[b] **[0.13, 0.71]** [$p = .006$]

Note. CI = confidence interval; GEE = generalized estimating equations.
[a] The negative binomial regression is restricted to observations in which an event occurred. Both models include linear and quadratic trends. Standard errors are robust and adjusted for state-level clustering. Nevada was excluded from the models because of outlying data that prevented model convergence. [b] Coefficient is statistically significant from zero ($p < .05$), also shown in bold type.

should be to limit potential shooters' access to firearms generally. One interpretation of our findings is that requiring permits to purchase or possess a firearm may limit potential shooters' access to firearms. Furthermore, laws requiring permits to purchase or possess firearms may be more effective than universal background checks because they rely on state or local officials, who have the most direct access to criminal, mental health, and drug- and alcohol-related records. In contrast, universal background checks rely on FBI data, which are often incomplete.

Second, to reduce the severity of mass public shootings when they do occur, the primary goal should be to limit the number of shots that can be fired before the shooter has to reload. This can be accomplished by restricting ammunition magazines to no more than 10 rounds. The 1994 Assault Weapons Ban is an example of a policy that sought to limit the severity of mass shootings. Included in that legislation was a ban on magazines that could hold more than 10 rounds (United States Congress, 1994). Recently several prominent voices have called for a renewal of the Assault Weapons Ban (Ingraham, 2018). Because our results did not show any association between assault weapons bans and mass public shootings, it may be more effective to focus on magazine capacity rather than trying to define assault weapons in general.

Third, our failure to find a relationship between laws that prohibit people with a history of violence from possessing firearms and that require relinquishment of firearms by people who do become prohibited from possessing them may indicate weaknesses in the practical application of these laws. Few states have statutory-based procedures for confiscating firearms from people who are adjudicated for violent misdemeanors—such as domestic violence offenses—or who are served with protection orders (Zeoli et al., 2020). Future studies should examine not only the enactment of laws but also their enforcement.

The methods and findings of this paper have implications for future research in the area of state firearm laws and mass public shootings. First, we used clearly defined and explicit criteria to categorize both our predictor and outcome variables. The public availability of both our mass public shooting data set and the extended State Firearm Law Database will allow researchers to conduct their own analyses to further the work described here. Second, we have demonstrated the use of the zero-inflated negative binomial model to simultaneously but separately identify factors associated with the incidence of mass public shootings and with the number of victims when such an event occurs. Our results suggest that there are separate laws associated with the incidence and severity of mass public shootings; thus, modeling the effect of firearm laws in a simple count regression may not be sensitive enough to distinguish these relationships.

Limitations

By far, the most notable limitation of this study stems from the fact that we sought to investigate mass public shootings, a small subset of all mass shootings. The sample size for analysis was therefore unavoidably small ($N = 155$ events), resulting in fairly wide confidence intervals on many of our point estimates and making it difficult to conclude that laws we found to be unassociated with mass public shootings do not affect these events. The number of events in our analysis was considerably less than the 604 mass shootings examined by Webster et al. (2020) and the 344 mass shootings studied by Reeping et al. (2019) but was higher than the 69 high-fatality mass shootings examined by Klarevas et al. (2019), the 57 in Gius (2015), and the 44 in DiMaggio et al. (2019).

Compounding this problem is the fact that some of the state laws were enacted in a small number of states, further limiting the effective sample size and reducing our power to detect an effect of these laws if one exists. This is particularly true for the violent misdemeanor laws, which were in effect in only four states in 2018.

Finally, because we were unable to control fully for confounding factors that could explain the observed results, we cannot infer causality from this study. Nevertheless, we did control for a wide range of variables known to be associated with rates of firearm violence, including sociodemographic factors, household gun ownership, violent crime rate, firearm homicide rate, and suicide rate. Any unrecognized confounding variable would have to be not only associated with both the enactment of permit or magazine capacity laws and with mass public shootings but would also have to be not strongly associated with any of the above variables.

Conclusion

Despite these limitations, our estimates of the association between state permit requirements and the incidence of mass public shooting events and between large-capacity magazine bans and fatalities and injuries occurring in such events were robust to different model specifications and are consistent with the findings of previous research. In particular: (a) our GEE logistic regression estimates and zero-inflated negative binomial estimates of the association between gun permit laws and the incidence of mass shootings were nearly identical and (b) our estimates of the association between large-capacity magazine bans and the number of fatalities as well as number of nonfatal injuries were also nearly identical when modeled using a zero-inflated negative binomial model and when modeled using a negative binomial regression model restricted to observations in which a mass public shooting occurred.

This study provides evidence that state laws requiring permits to purchase a gun are related to a lower incidence of mass public shootings and that state bans on large capacity magazines are related to fewer fatal and nonfatal injuries when such events do occur. Policymakers wanting to address specifically the morbidity and mortality from mass shootings would be prudent to adopt permit-to-purchase laws and large-capacity ammunition magazine bans to reduce both the incidence of mass public shootings and the number of casualties if such events do occur. They should take these findings into account in combination with the substantial body of research on the effect of state firearm laws on other types of firearm violence (Morral et al., 2018; Siegel, Pahn, et al., 2019) and with consideration of citizens' right to bear arms under the Second Amendment of the U.S. Constitution (*McDonald v. City of Chicago,* 2010).

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