

## What Do We Know About the Association Between Firearm Legislation and Firearm-Related Injuries?

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Firearms account for a substantial proportion of external causes of death, injury, and disability across the world. Legislation to regulate firearms has often been passed with the intent of reducing problems related to their use. However, lack of clarity around which interventions are effective remains a major challenge for policy development. Aiming to meet this challenge, we systematically reviewed studies exploring the associations between firearm-related laws and firearm homicides, suicides, and unintentional injuries/deaths. We restricted our search to studies published from 1950 to 2014. Evidence from 130 studies in 10 countries suggests that in certain nations the simultaneous implementation of laws targeting multiple firearms restrictions is associated with reductions in firearm deaths. Laws restricting the purchase of (e.g., background checks) and access to (e.g., safer storage) firearms are also associated with lower rates of intimate partner homicides and firearm unintentional deaths in children, respectively. Limitations of studies include challenges inherent to their ecological design, their execution, and the lack of robustness of findings to model specifications. High quality research on the association between the implementation or repeal of firearm legislation (rather than the evaluation of existing laws) and firearm injuries would lead to a better understanding of what interventions are likely to work given local contexts. This information is key to move this field forward and for the development of effective policies that may counteract the burden that firearm injuries pose on populations.

death; firearms; homicide; legislation; suicide; weapons; wounds and injuries

Abbreviations: NCHS, National Center for Health Statistics; NFA, National Firearms Agreement; UCR, Uniform Crime Reports.

### INTRODUCTION

Firearms account for a substantial number of external causes of death across the world. In 2000, for example, it has been estimated that globally between 196,000 and 229,000 persons died from nonconflict firearm-related injuries (1). Global estimates from 2010 indicate that the rates of firearm homicides and unintentional firearm injuries for this year were 2.5 and 0.7 per 100,000, respectively (2). Although less clear estimates for global firearm suicide rates are available, among high-income countries, the United States has one of the highest rates (5.8 per 100,000) (3). In the United States, 31,672 persons died from firearm injuries in 2010, at an age-adjusted rate of 10.1 per 100,000, and this has remained relatively unchanged since 2000 (4, 5).

Governments around the world have adopted a range of approaches to regulate the access and use of firearms in the general population, aiming to reduce firearm-related crime and

mortality rates (Table 1). The variety of laws is matched by the diversity of ways in which laws are implemented, the heterogeneity in law enforcement efforts, and the severity of penalties associated with legal violations.

This heterogeneity in approaches and implementation methods makes it critical to identify approaches that are less likely to be effective and to identify which strategies, looking forward, may be more likely to work (5–8). In addition, examining the associations between specific policies and firearm-related deaths across countries can improve our understanding about which types of laws are more likely to be successful in reducing firearm mortality rates in similar contexts or within diverse legal frameworks. This review aimed to examine the association between firearm-related laws and the rate of firearm-related suicides, homicides, and unintentional injuries and deaths worldwide. Previous literature reviews assessing this issue (6–11) have focused mainly on US studies.

**Table 1.** Categorization of Firearm-Related Laws<sup>a</sup>

Categories	Types of Laws
Use	Right to carry or shall issue laws
	Hunting laws
	Stand your ground and castle doctrine laws
	Ordinances against publicly firing a gun
Sales	Licensing and inspections of dealers
	Record-keeping requirements
	Background checks
	Waiting periods
	Requirement to report multiple sales
	One-handgun per month laws
	Zoning ordinances barring gun shows on public property
Ownership	Bans on purchases or possession by felons, youths, other presumably high-risk groups, and those with mental conditions
	Licensing for owners and permits for firearms
	Required training on safe firearm use
	Requirement to notify police of stolen firearms
Safer storage	Child access prevention laws
	Other safe storage requirements
Firearms and ammunition	Bans on automatic and semiautomatic firearms; high-capacity ammunition magazines; and inexpensive, poor-quality firearms (e.g., Saturday night specials)
Punishment for firearm offenders	Penalties and sentences for firearm misuse
Voluntary rendition of firearms	Firearm buyback programs

<sup>a</sup> Adapted from Cook and Goss (146).

We conducted a systematic literature review of empirical studies directly assessing the association between firearm-related laws at the local, regional, and national levels and the rate of firearm-related homicides, suicides, and unintentional injuries/deaths. We defined firearm-related laws as any law on regulations or restrictions on the use, sale, ownership, storage of firearms, those banning specific types of firearms or ammunition, those modifying the penalties and sentences for firearm misuse, and those promoting voluntary rendition of firearms through buyback programs.

## METHODS

We reviewed peer-reviewed and non-peer-reviewed published studies between 1950 and 2014. Given the fact that laws are enacted and implemented in social contexts and are not controlled by researchers as in an experimental study, evidence of the consequences of these laws is likely to be generated from observational ecological cross-sectional or longitudinal studies. Although these studies have limitations related to confounding, the uncertainty of a temporal sequence, and

variation in the laws and enforcement across units of observation, they provide an alternative when it is not feasible to conduct randomized controlled trials for policy interventions. Therefore, our inclusion criteria included observational ecological studies examining the association between firearm-related laws and firearm-related suicides, homicides, and unintentional injuries/deaths at the national or local level. No randomized trials were available on this topic.

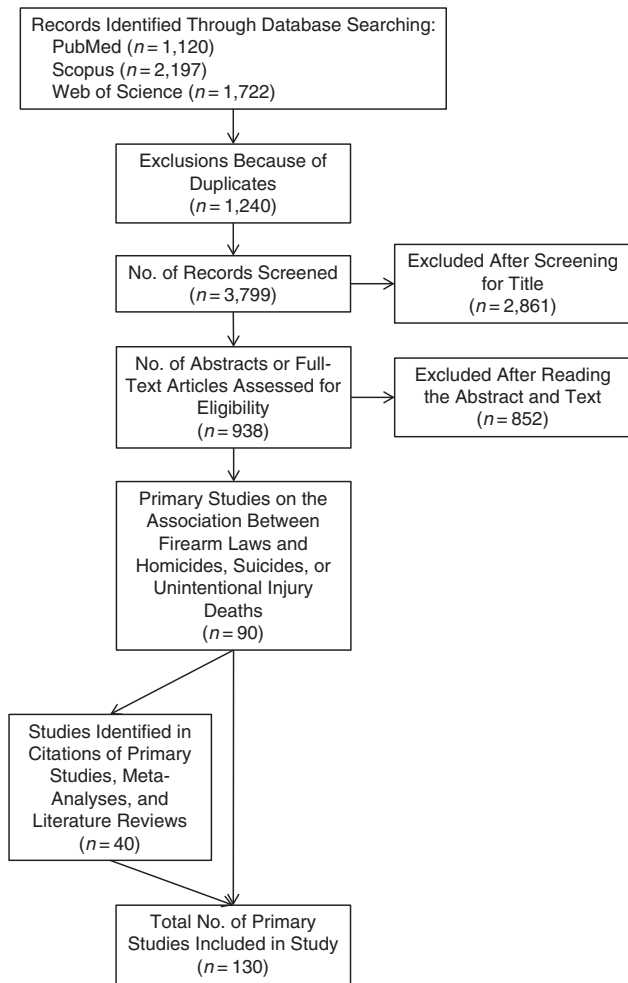
We searched the PubMed, Scopus, and Web of Knowledge databases to capture evidence from cross-sectional and longitudinal studies in diverse fields including the social, medical, political, and criminology sciences. We also searched for studies cited in previous literature reviews and books on this topic, as well as studies cited in the reference lists of the original articles identified through our search.

The search was conducted in the English language but covered studies in other languages (e.g., French, Spanish, or Portuguese) if abstracts were available in English so they could be detected in our search or if studies were cited in reviewed studies. We used keywords/Medical Subject Headings terms for the searches that included a combination of the following: 1) firearm terms (firearms, weapons, gun, handgun); 2) gun-control law terms (law enforcement, storage, trafficking, safety, carry, permit, ban, legislation, regulation, control, formal, background check, child safety locks, childproof handguns); and 3) health outcome terms (impact, assessment, trends, mortality, wounds, injuries, suicide, homicide). We also searched citations in primary studies and literature reviews on the topic.

We excluded studies that did not assess the association between firearm-related laws and homicides, suicides, or unintentional injuries/deaths; studies in which firearm deaths were reported as part of a combined outcome but specific results for firearm death rates were not reported; longitudinal studies reporting only average rate comparisons in pre/post law periods; or those reporting descriptive changes in rates but not using any statistical method to compare rates.

A total of 5,039 studies were retrieved by using the Medical Subject Headings/keywords terms in selected search engines: PubMed ( $n = 1,120$ ), Scopus ( $n = 2,197$ ), and Web of Science ( $n = 1,722$ ). After exclusion of duplicates and those not meeting the inclusion or exclusion criteria after title screening ( $n = 2,861$ ) and after reading the abstract or text ( $n = 852$ ), a total of 90 primary studies were identified. In addition, we identified 40 articles cited in selected studies or in reviews that met our inclusion or exclusion criteria for a total of 130 primary studies. A description of the number of studies that were included or excluded in our study is presented in Figure 1.

Design suitability and quality of execution of studies were assessed following criteria from the *Guide to Community Preventive Services* (12, 13). Although there are other instruments, such as the environmental health perspectives tool or the Cochrane risk of bias assessment tool, we used the criteria from this *Guide* given its applicability to the evaluation of ecological studies and because it has been used to examine studies on the effectiveness of firearm laws (9). In this review, assessments of studies were conducted by one of the coauthors. Longitudinal prospective or retrospective cohort studies with a concurrent comparison group and multiple pre/post intervention measurements were classified as having “greatest” design



**Figure 1.** Process of selecting studies examining the effects of firearm-related laws with firearm homicides, suicides, and unintentional deaths.

suitability; longitudinal studies without a concurrent comparison group but with multiple pre/post intervention measurements were classified as “moderate”; and cross-sectional studies or longitudinal studies without a concurrent comparison group and with only single pre/post intervention measurements or with only postintervention measurements were classified as “least” design suitability (Web Table 1 available at <http://aje.oxfordjournals.org/>). Potential limitations that could threaten the internal validity of studies are also presented in Web Table 1 (a description of limitations is provided in Table 2).

The reporting and description of findings from included studies adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (14).

## FINDINGS

Results are presented and described according to categories of firearm laws (Table 1) and then according to specific

types of laws within these categories. A summary of different laws evaluated by studies in this review is provided in Table 3. A description of studies reviewed here, including data, study design ratings, results, and potential limitations, is summarized in the Web Table 1. Most studies used a cross-sectional time-series design to compare rates and rate trends between pre/post-law periods. The majority of studies conducted in the United States compared states with and without laws over time while controlling for potential confounders. In addition, US cross-sectional studies frequently used an index of strictness of firearm laws to examine the association between laws and firearm deaths (Web Table 1). Most international studies assessed the association between combinations of laws being simultaneously implemented and different outcomes using pre/post-law period comparisons at the national level without a control group. Of all studies, 47.69% fit the “greatest,” 20% fit the “moderate,” and 32.31% fit the “least” design criteria.

We also provide a summary of results from some studies in Figures 2–4. Results are grouped according to the laws being examined across studies and the different outcomes. A summary of results for the association between laws restricting firearm use and homicides is shown in Figure 2. The results for the association between all other laws and homicides and suicides/unintentional deaths are shown in Figures 3 and 4, respectively.

### Laws targeting firearms use

*Licenses to carry concealed firearms or “shall issue” laws.* These laws allow qualified individuals to carry concealed firearms (Table 3). In the United States, Lott and Mustard (15) using a times-series design approach and data from the Federal Bureau of Investigation’s Uniform Crime Reports (UCR) (1977–1992) identified that shall issue laws were associated with lower rates of homicides at the county and state levels. Bronars and Lott (16) also noted evidence that shall issue laws were associated with an apparent increase in the rate of homicides in adjacent counties without shall issue laws (16). Seven other studies (17–23) supported Lott and Mustard’s findings. However, others found inconsistent results when using different modeling strategies (24–31) and suggested the presence of errors in the data used in this study (32). Ayres and Donohue (33–35) used Lott and Mustard’s data and found, after recoding the data and varying model specifications, that shall issue laws were not associated with reductions in homicide rates. Particularly, they demonstrated that using county data introduced severe bias and that results were not robust to model specifications (such as including more year data or weighting strategies). Wellford et al. (36) from the National Research Council reached similar conclusions. In addition, Grambsch (37) found that controlling for regression to the mean diluted the association between shall issue laws and homicides. Using additional data from the National Center for Health Statistics (NCHS), Rosengart et al. (38) and Hepburn et al. (39) showed no association between these laws and overall and firearm homicides. Studies comparing cities with a population of 100,000 or more (40) and others using samples of large cities in the United States (41, 42) found similar findings. Another study (43) looking at injury data from southern Arizona found higher

**Table 2.** Potential Limitations in the Execution of Studies That Could Threaten Their Internal Validity

Category	Specific Items
Descriptions	The study population not well described
Sampling	Limited year data (period studied) to identify the effects of the intervention County level covariates with missing data excluding counties from analysis No clear description of the units (e.g., states) included in analyses Convenience sample No clear description of the criteria used for inclusion of units (e.g., states) in the study
Exposure measurement	No clear details on source of the exposure variable No validated scale for exposure classification Exposure variable with some percentage of missing data Coding errors in exposure variable No clear description of the laws that were being examined
Outcome measurement	No clear details on source of the outcome variable Outcome variable with some percentage of missing data No reliable county data Other relevant outcomes not examined
Data analysis	No use of alternative analytical strategies to account for dynamic trends of time-series data <sup>a</sup> Inappropriate or unclear operationalization of variables No information on statistical strategies used in analyses Statistical testing model not appropriate to answer question No alternative strategies to test for robustness of findings given other model specifications <sup>b</sup> Covariates with large percentage of missing data
Confounders <sup>c</sup>	No adjustment for other potential confounders No information on covariates used in analyses Risk of collinearity because of adjustment for a vast number of confounders No clear details on source of the covariates
Follow-up period	Not applicable for studies included in this review
Other	Results from statistical tests not presented Disaggregated results for single units not provided Results of some analyses described in methods not provided in the text Subpopulation being studied not a target of the laws

<sup>a</sup> Alternative analytical strategies to account for dynamic trends of time-series data: strategies to examine whether trends are abrupt, delayed, gradual, or constant, with comparison of slopes in pre- and postlaw periods, as well as hybrid models (both dummy and spline/trends specifications).

<sup>b</sup> Alternative strategies to test for robustness of findings given other model specifications: inclusion/exclusion of years of data, different sets of covariates, fixed year effects, fixed state effects, state-specific trend effects, lag of intervention or covariates, years of available pre- and postlaw data across states or cities, exclusion of states/cities with unusually high rates of the outcome, weights for population size, clustering of errors at the state level, and log transformations of covariates.

<sup>c</sup> Potential confounders of the laws-homicides association: baseline state-level firearm prevalence; percent of population that is white, black, or Hispanic; percent of males aged 10–24 or 15–24 years; state average median family income; percentage of the population residing in a metropolitan area; unemployment rate; alcohol consumption rates; percentage living under poverty threshold; incarceration rates; law enforcement officers per capita; and other laws and concurrent events influencing the use and availability of firearms during the period of observation. Potential confounders of the laws-suicides association: baseline state-level firearm prevalence, marriage rates and divorce rates, unemployment rates, state average median family income, and the percentage of males aged 15–24 years, and other laws and concurrent events influencing the use and availability of firearms during the period of observation.

proportions of firearm injuries/deaths associated with shall issue laws.

In recent years, studies by Strnad (44) using a Bayesian approach and by Moody and Marvell (45, 46), Lott (47), and

Gius (48) showed that shall issue laws were associated with reductions in homicide rates (extending data to 2000). Ayres and Donohue (49, 50) responded to the studies by Moody and Marvell (45, 46) showing the inconsistency of results when

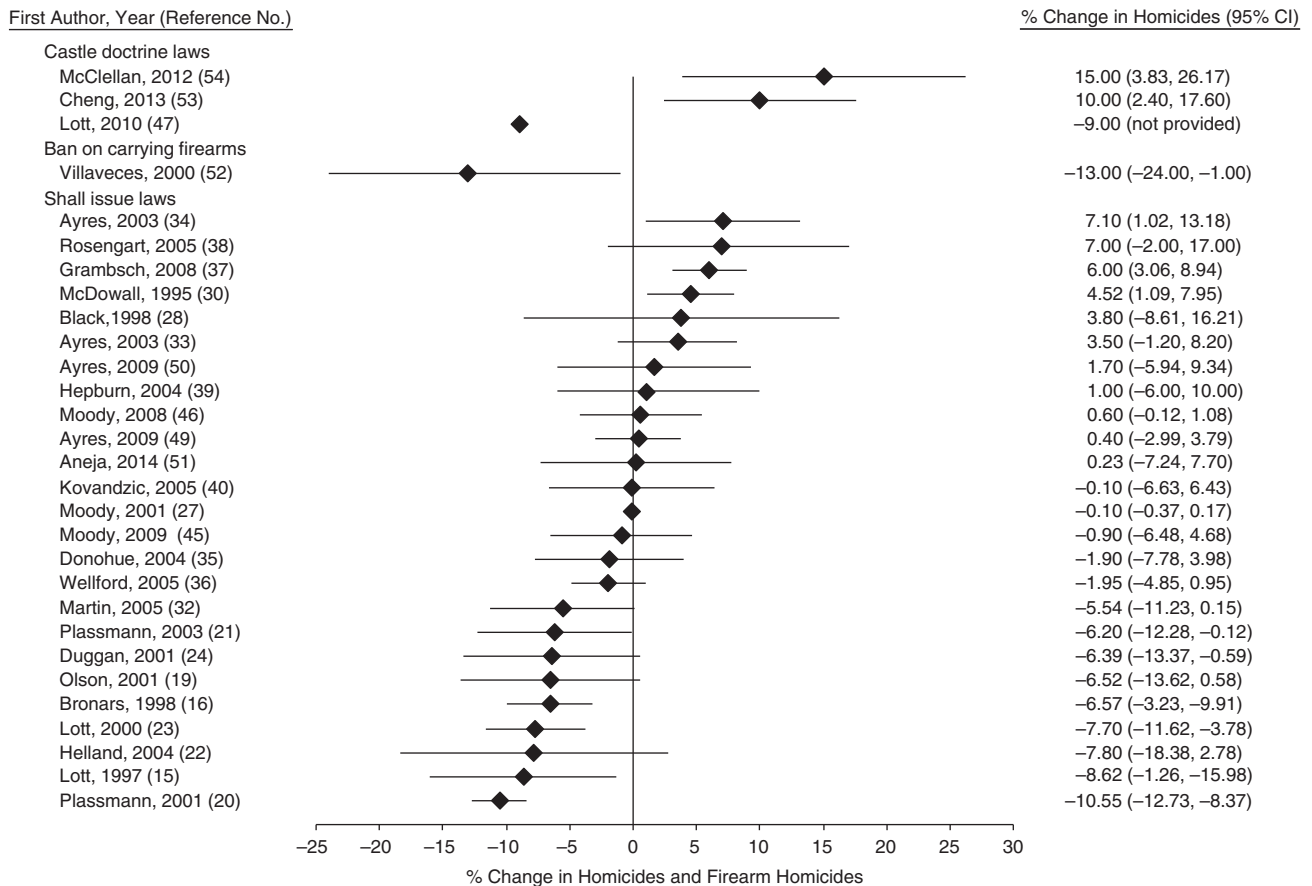
**Table 3.** Laws Examined in Primary Studies

Firearm Law	Date of Enactment	Description
"Shall issue" or "right to carry" laws (United States)	Different enactment dates for each state	These laws allow qualified individuals to carry concealed firearms. Qualified individual criteria require that eligible individuals have no felony convictions, no pending domestic violence orders, no drug or alcohol disorders or charges, and no hospitalizations in a mental institution. Individuals usually must also have American citizenship, state citizenship, and county residency; have met the minimum age requirement; and have a certificate of completion of a firearm safety course. In addition, some states have may-issue laws, which are laws containing language suggesting that a qualified individual could be denied the permit to carry concealed firearms (36).
Gun Control Act of 1968 (United States)	October 22, 1968	This law banned the sale of Saturday night specials (handguns), blocked the importation of firearms that did not meet criteria for being classified for sporting or scientific purposes, prohibited dealers from shipping firearms to other states and prohibited the sale of firearms to buyers without state identification, implemented license requirements for firearm sellers and owners, and banned possession and purchasing of firearms by minors (under 18 years for rifles and 21 years for handguns) and high-risk-group individuals (persons convicted of a felony, mental health problems, or illegal drug users) (147).
Florida felony firearm law (United States)	October 1, 1975	This law mandated a 3-year sentence for possessing a firearm or destructive device while committing or attempting to commit any of the specified felonies in the law (including murder, sexual battery, robbery, burglary, and aggravated assault). Sentences could not be suspended, deferred, or withheld, and the defendant could not be eligible for parole until the minimum 3 years had been served (85).
Massachusetts gun control law (United States)	April 1, 1975	This law mandated a 1-year minimum prison term for the unlicensed carrying of firearms. In addition, the law required a Firearms Owner Identification card to own or possess either firearms or ammunition. Sentences could not be suspended, and the defendant could not be eligible for parole until at least 1 year had been served (79).
District of Columbia 1976 law (United States)	July 23, 1976	This law required that every person who owned and had firearms should register them under the provision of the 1968 law and should reregister them with the Metropolitan Police Department 60 days after the effective date of the Act. New rifles and shotguns could be registered if purchased from a licensed dealer and after passing a background check for criminal records and history of substance use or mental health problems. The law also strengthened safe storage requirements, including keeping firearms unloaded or bound by a trigger-locking device (97, 148).
Michigan Felony Firearm Law (United States)	February 11, 1976 (effective date: January 1, 1977)	This law mandated a 2-year sentence for possessing a firearm for felonies committed with or in possession of firearms. Sentences could not be suspended, deferred, or withheld, and the defendant could not be eligible for parole until the minimum 2 years had been served (84).
New Jersey "Graves Amendment" (United States)	February 12, 1981	This law mandated a minimum sentence of imprisonment for any person involved in a crime who was in possession of a firearm. The minimum sentence also applied to those convicted of possession of a firearm with intention to use against another person. Sentences could not be suspended, and the defendant could not be eligible for parole until the mandatory sentence had been served. The minimum sentence was one third to one half of the total sentence imposed or 3 years, whichever was greater, for first, second, and third degree crimes and 18 months for fourth degree crimes (87).
1986 Detroit law (United States)	November 26, 1986	This law imposed mandatory jail sentences of 30–90 days and a fine of \$100–\$500, depending on whether or not it was a first conviction under the ordinance, on anyone convicted of unlawfully concealing a pistol or carrying a firearm (88).
1994 Brady Handgun Violence Prevention Act (United States)	November 30, 1993	The Brady Act instituted federal background checks on firearm purchasers from a federally licensed dealer, manufacturer, or importer. Prohibitions applied to an individual convicted in any court of a crime punishable by imprisonment for a term exceeding 1 year, fugitives from justice, unlawful user of or addicted to any controlled substance, persons with mental conditions or committed to a mental institution, a person being unlawfully in the United States, a person with a court restraining order for domestic violence, or convicted in any court of a misdemeanor crime of domestic violence (149).
1994 Federal assault weapons ban (The Public Safety and Recreational Firearms Use Protection Act) (United States)	September 13, 1994	This law banned the manufacture, transfer, sale, and possession of certain semiautomatic weapons and large-capacity ammunition magazines. Semiautomatic weapons fire a bullet each time the trigger is squeezed, loading the next bullet after each shot. Weapons already in possession at the time of the law's enactment were grandfathered. The law was enacted in 1994 and expired in 2004. None of the attempts to renew it has prospered (76).
Maryland Gun Violence Act (United States)	Effective date: October 1, 1996	This law set stronger restrictions to prevent firearm purchases including background checks and registration of handguns sold by private gun owners, 1 handgun purchase per month, and greater authority given to police and judges to confiscate firearms from domestic violence offenders (77).

Table continues

Table 3. Continued

Firearm Law	Date of Enactment	Description
Castle doctrine laws and stand your ground laws (United States)	Different enactment dates for each state	These laws include those eliminating the duty to retreat before using lethal force against an assailant in one's own home and a list of other places and those removing any civil liability for those acting under that law and under the principle of self-defense (53, 54).
Bill C-51 (Canada)	August 5, 1977	This law increased sentences (1–14 year consecutive sentence for the actual use of a firearm to commit an indictable offense; stricter penalties for firearm homicides) and required permits for firearm sellers and certificates for buyers; the law also included provisions dealing with new offenses, search and seizure powers, and prohibitions to sell fully automatic weapons unless registered as restricted weapons before January 1, 1978. In addition, the law included specific procedures to store firearms and the elimination of permits to carry guns to defend property (150).
Bill C-17 (Canada)	December 5, 1991	This law implemented stricter storage requirements and stricter restrictions to purchase firearms including photographs and personal references. A 28-day waiting period and mandatory courses for safe handling and storage for new gun owners were also required. The law also included new restrictions for prohibited weapons, including automatic, semiautomatic, and military firearms and those with large-capacity cartridge magazines. In addition, the law also increased penalties for crimes committed with firearms (150).
Bill C-68 (Canada)	December 5, 1995	This law included minimum sentences for individuals committing crimes while carrying firearms, a more organized regulatory process for licensing and registration of firearms, a license to purchase firearms and ammunition, a requirement for spousal notification, and registration of all firearms including rifles and shotguns (150).
The 1996 National Firearms Agreement (Australia)	Government's agreement date: May 10, 1996	The National Firearms Agreement included banning the importation, ownership, sale, transfer, possession, manufacture, or use of all self-loading center rifles, all self-loading and pump action shotguns, and all self-loading rim fire rifles. The law included the following: implementation of a buyback program for prohibited firearms; mandatory registration of all firearms; licensing requirements proving genuine reason for owning a firearm; being at least 18 years of age to buy guns; a 28-day waiting period to purchase a firearm; requirement of a separate permit for each firearm purchased; certification of being mentally and physically fit to own, possess, and use a firearm; required background checks for gun sales; for recreational and hunting purposes, required membership of an authorized shooting club or permission from a hunting land owner; strict firearm storage requirements; licenses for firearm dealers and all records of sales to be provided to the police; restrictions to purchase ammunition (quantities within a time period) and only for the licensed firearms owned by the buyer; and an accredited training course certificate in firearm safety for new applicants (151, 152).
National "Army XXI" reform (Switzerland)	January 1, 2004	The national reform that reduced by half the number of active soldiers, increased the fee to purchase a military gun, and implemented license requirements for gun owners (68).
1977 South Australia Firearms Act (Australia)	May 12, 1977	This regulation required a license for firearm purchases; new owners were required to pass an examination on the handling and safety of weapons. The law also included increments in the severity of penalties for firearm offenders and registration of all firearms (153).
Estatuto do Desarmamento (Brazil)	December 22, 2003	This law tightened restrictions on the possession and commercialization of firearms and ammunition, banned the carrying of firearms, implemented requirements for the registration of firearms, increased firearm costs, and established stronger penalties for illegal trafficking of firearms. In addition, background checks were implemented for firearm sales that included checking for criminal and mental health records. The minimum age to purchase was increased to 25 years (154).
The 1997 firearm law (Austria)	July 1997	This law included background checks for category B weapons (handguns, semiautomatic firearms, repeating firearms, or single shot firearms with center fire percussion) in addition to psychological testing; also, the law required a 3-day "cooling-off" waiting period for category C and D weapons including long firearms with a smooth bore and rifled barrels and other semiautomatic long firearms. The law increased the minimum age to purchase to 21 years and also included safer firearm storage regulations (123).
Amendment to the Arms Act (New Zealand)	October 27, 1992	The law required licensing for dealers and licensing for firearm owners that included the following: passing a test on knowledge of the Firearms Code and rules of firearm safety; police assessments of the applicant and the applicant's home that include checks for firearm storage, security, and social arrangements; and interviews with 2 referees of whom one was a partner or parent in a process that could take 8–12 weeks. The law also included stricter safe storage requirements with ammunition being kept separately from firearms (125).
Firearms Control Act (South Africa)	October 2000	This law required firearm licenses for firearm purchases; the licensing process required background checks (criminal and mental health records) of applicants to be submitted to the registrar, completion of training, and passing a test on the efficient and safe handling of firearms. The law also required an additional license per each gun owned. Fully automatic guns were banned, and the minimum age to purchase and carry firearms was increased to 21 years (155, 156).



**Figure 2.** Summary of results from studies examining the effects of laws targeting firearms use (shall issue or right to carry laws, bans on carrying laws, and castle doctrine and stand your ground laws) on homicides and firearm homicides. We present only a single estimate from each study because of space limitations. We selected the estimates from models that, to our consideration, included the most important model specifications. We present the results from studies with comparable results in terms of percent change in firearm deaths (when not provided, we calculated the percent change if there was available information for calculations). Stand your ground laws are presented with castle doctrine laws. The estimate in Grambsch (37) represents the percent annual change in the rate of homicides in the postlaw period compared with the prelaw period. CI, confidence interval.

using alternative model specifications and suggesting that county data should not be used. The study by Aneja et al. (51) that included different model specifications also suggested that shall issue laws were not associated with reduction of homicides. A summary of study results for the association between shall issue laws and homicides is shown in Figure 2.

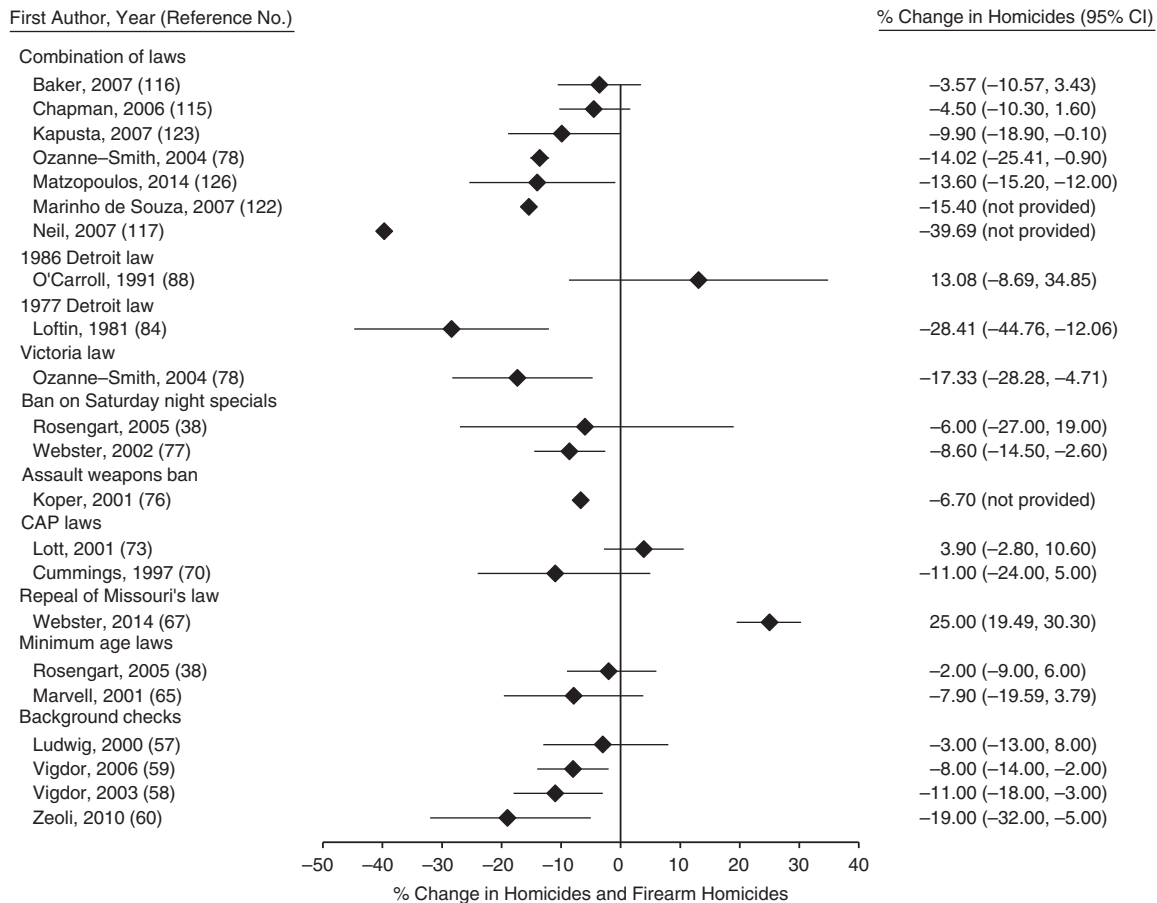
In Colombia, Villaveces et al. (52) examined the association between laws banning the carrying of firearms during weekends after paydays, holidays, and election days in Cali and Bogota and the rate of homicides. In an interrupted time series with multiple replications comparing the rates of homicides on days with and without the restriction, these authors identified a 14% reduction in all homicide rates in Cali during intervention days compared with days without it. The intervention was associated with a 13% reduction in firearm homicides in Bogota.

*“Castle doctrine” laws and “stand your ground” laws.* These laws eliminate the duty to retreat before using lethal force against an assailant in one’s own home and remove

civil liability for those acting under the principle of self-defense (Table 3). Lott (47), using time-series models and data over the 1977–2005 period, observed that castle doctrine laws were associated with a 9% reduction in homicide rates. In contrast, Cheng and Hoekstra (53) compared states during the 2000–2010 period using a differences-in-difference approach (UCR data) and found that these laws were associated with a 6%–11% increase in homicide rates. With a similar approach to that of Cheng and Hoekstra (53) but using NCHS monthly data (2000–2010), McClellan and Tekin (54) found that stand your ground laws were associated with a 6.8% increase in homicide rates, mainly driven by increments (14.7%) in homicide rates among white males; other self-defense provisions were not consistently associated with homicides.

**Laws targeting firearms sales**

Cross-sectional studies assessing the association between background checks/waiting periods and firearm deaths provide



**Figure 3.** Summary of results from studies examining the effects of firearm laws (firearms sales, firearms ownership, firearms storage regulations, laws targeting specific firearms and ammunition, sentences and punishment for gun offenders, and combinations of laws being simultaneously implemented) on homicides and firearm homicides. We present only a single estimate from each study because of space limitations. We selected the estimates from models that, to our consideration, included the most important model specifications. We present the results from studies with comparable results in terms of percent change in firearm deaths (when not provided, we calculated the percent change if there was available information for calculations). The estimate in Chapman (115) represents the ratio between pre- and postlaw trends; the estimate in Kapusta (123) represents the difference between pre- and postlaw trends; the estimate in Ozanne-Smith (78) represents the percent change in the rate of firearm deaths; and the estimate in Matzopoulos (126) represents the percent annual change in the rate of firearm homicides in the postlaw period. CAP, child access prevention; CI, confidence interval.

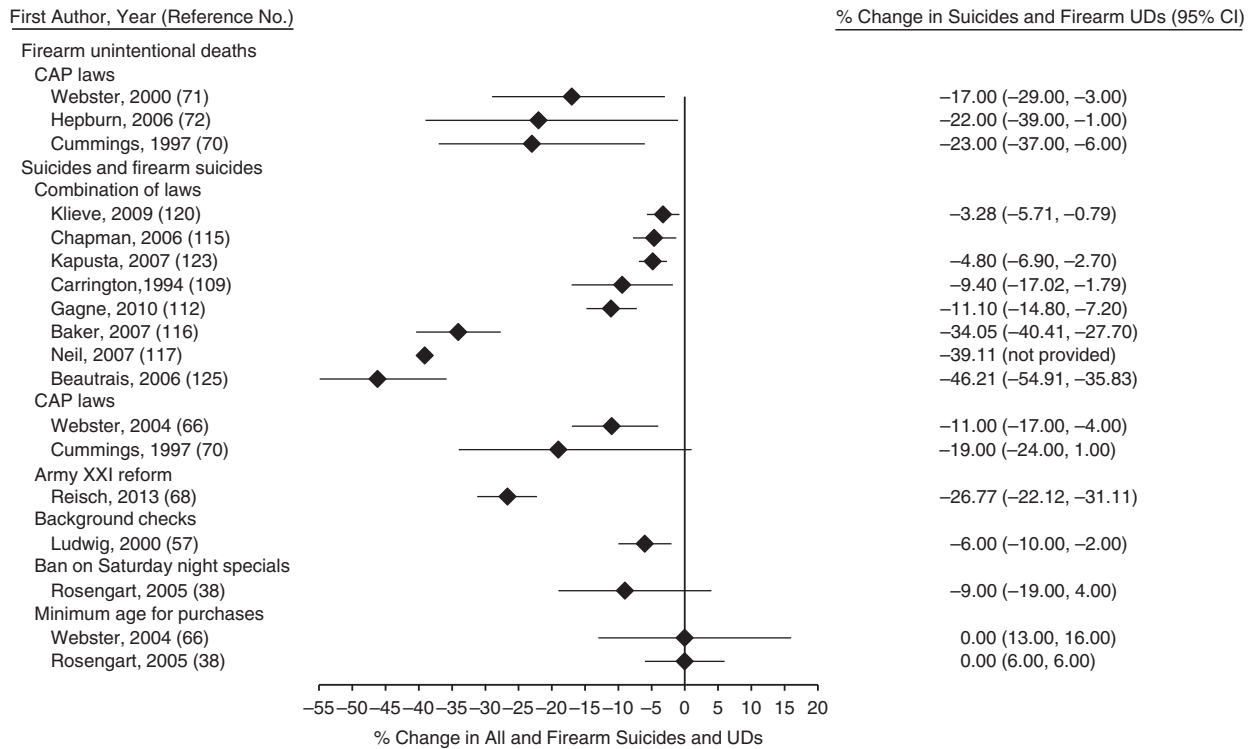
mixed results. Kleck and Patterson (7) used data from 170 US cities (1979–1981) and found no association between waiting periods and homicides or suicides; however, firearm purchase bans for those with mental health conditions were associated with fewer homicides. Ruddell and Mays (55) using a scale to rate the state's ability to screen individuals found that more stringent background checks were associated with reductions in firearm homicides. Sumner et al. (56) wrote that local checks (as opposed to federal) for local mental health and court restraining records were associated with lower suicide rates, but not with homicide rates, among adults aged 21 years or older.

Longitudinal studies have also examined these laws. Lott and Mustard (15) using time-series analyses and UCR data from counties and states in the United States found no associations between waiting periods and homicide rates at the state level (inconsistent results at the county level). Similar

findings were previously reported by McDowall et al. (30) using data from 5 cities. Ludwig and Cook (57) compared 32 “treatment” states directly affected by the Brady Act against 18 “control” states that already had similar restrictions (NCHS data, 1985–1997). No associations between the Brady Act and firearm homicides among adults (aged 21 years or older and 55 years or older) were observed. However, in states that included changes in waiting periods, the law was associated with fewer firearm suicides only among those aged 55 years or older. More recently, Lott (47) using state-level data found no significant associations between the Brady Act and homicide rates. In contrast, La Valle (41), comparing 20 large cities in the United States by using UCR data (1990–2000), found that the Brady Act was associated with reductions in all and firearm homicide rates.

Other studies examined specific aspects of these laws. Vigdor and Mercy (58, 59), using UCR data (1982–1998),





**Figure 4.** Summary of results from studies examining the effects of firearm laws (firearms sales, firearms ownership, firearms storage regulations, laws targeting specific firearms and ammunition, and combinations of laws being simultaneously implemented) on suicides and firearm suicides and unintentional deaths. We present only a single estimate from each study because of space limitations. We selected the estimates from models that, to our consideration, included the most important model specifications. We present the results from studies with comparable results in terms of percent change in firearm deaths (when not provided, we calculated the percent change if there was available information for calculations). The estimates from Klieve (120) and Chapman (115) represent the ratio between pre- and postlaw trends; the estimate from Kapusta (127) represents the difference between pre- and postlaw trends; and the estimate from Gagne (112) represents the percent annual change in the rate of firearms in the postlaw period. CAP, child access prevention; CI, confidence interval; UD, unintentional death.

found that states with laws preventing subjects with domestic violence restraining orders from owning/purchasing firearms had a 9% reduction in the rates of intimate partner, female intimate partner, and female intimate partner firearm homicides; however, there was no association between these outcomes and restrictions for those convicted of domestic violence misdemeanors. Zeoli and Webster (60) also described similar findings using data from 46 of the largest cities in the United States (1979–2003). In addition, Rodríguez Andrés and Hempstead (61), using NCHS data from 1995 to 2004, found that purchasing restrictions for mental health issues and domestic violence convictions were associated with lower rates of male suicides in some age groups. Sen and Panjamapirom (62), using NCHS data from 1996 to 2005, found that, compared with states checking for criminal backgrounds only, there were lower homicide rates in states additionally checking for restraining orders and lower suicide rates in states also checking for mental conditions, fugitive status, and misdemeanors.

Particularly on laws regarding licensing of dealers, Kleck and Patterson (7) in a cross-sectional study found an association between these laws and reductions in homicide rates but not in suicide rates. Moreover, Irvin et al. (63), using NCHS data

(1995–2010) in adjusted models, found that licensing requirements for dealers were associated with firearm homicide reductions.

**Laws targeting firearms ownership**

Two cross-sectional studies (7, 64) found that permits and licenses to purchase firearms were associated with lower rates of firearm suicides. In a longitudinal study using NCHS data (1970–1998), Marvell (65) found that laws restricting juvenile access to firearms were not associated with all or firearm homicide or suicide rates among youth. Studies using times-series analyses from Webster et al. (66) and Rosengart et al. (38) did not find evidence of reductions in firearm deaths associated with state and federal laws raising the legal age to 18 or 21 years for handgun purchases/possession. Rodríguez Andrés and Hempstead (61) in unadjusted models found that minimum age requirements were associated with fewer suicides among males.

Interestingly, Webster et al. (67) examined the association between Missouri’s 2007 repeal of the permit-to-purchase handgun law, which required all handgun purchasers to have a valid license to purchase handguns, and homicide rates.

Using NCHS (1999–2010) and UCR (1999–2012) data, these authors found that repeal of the law was associated with a 25% increase in firearm homicide rates in Missouri.

In Switzerland, Reisch et al. (68) examined the association between the national army XXI reform and suicide rates; this reform reduced by half the number of active soldiers, increased the fee to purchase a military gun, and implemented license requirements for gun owners (Table 3). The overall suicide and firearm suicide rates were lower than predicted among males aged 18–43 years (targeted population), without changes among control groups (women aged 18–44 years and males aged 44–53 years). In Norway, Gjertsen et al. (69) examined different firearm laws using piecewise regression models (1969–2009 data). Their findings suggested that the 1990 restrictions requiring permits for firearm purchases were the only firearm ownership laws likely contributing to reductions in suicides rates.

### Laws targeting firearms storage regulations

Cummings et al. (70) examined the association between child access prevention laws and firearm deaths using an ecological time-series design and NCHS data (1979–1994). These authors found that child access prevention laws were associated with fewer unintentional firearm deaths among children under the age of 15 years, but not among older ones. Results were pronounced in 3 states that allowed felony prosecution of law offenders, especially Florida and California. Similar results were found by Webster and Starnes (71) using NCHS data (1979–1997) and Hepburn et al. (72) using NCHS data (1979–2000) in more complex models, with Florida driving most of the association (the authors suggest that the low number of unintentional deaths in some states may have resulted in limited power to identify significant associations (72)). Only Lott and Whitley's (73) study using UCR data (1977–1996) in time-series weighted tobits analyses found that child access prevention laws were not associated with unintentional firearm deaths.

Regarding suicides and homicides, no clear association between child access prevention laws on these outcomes was observed by Lott and Whitley (73), who indicated that Poisson models suggested a decline in firearm suicides and an increment in homicides, or by Lott (47) (with homicides). In contrast, Webster et al. (66) found that child access prevention laws were associated with a reduction in all suicide and firearm suicide rates among individuals aged 14–17 years (8.3% and 10.8% reduction, respectively) and those aged 18–20 years (11% and 13%, respectively). Cummings et al. (70) observed a reduction of 19% in firearm suicides and 11% in firearm homicides among children aged 15 years or younger, almost reaching significance (95% confidence intervals: 0.66, 1.01 and 0.76, 1.05, respectively).

Other studies focused on hospital discharge data. A cross-sectional study by Lee et al. (74) found that child access prevention laws were associated with increments in firearm injuries. A longitudinal study by DeSimone et al. (75) using information from 11 states, of which 7 passed child access prevention laws between 1988 and 2003, found that child access prevention laws were associated with lower nonfatal firearm injuries among individuals under the age of 18 years.

In Norway, Gjertsen et al. (69) found that the 2003 home guard firearm law implementing safer storage requirements was likely contributing to reductions in homicide rates among males.

### Laws targeting specific firearms and ammunition

*1994 Federal assault weapons ban, United States.* This law banned the sales and ownership of semiautomatic firearms and large-capacity ammunition magazines. Koper and Roth (76) using UCR data (1980–1995) found no association between the law and homicide rates in 15 states after adjusting for the presence of other firearm laws and crime laws in New York and California. A recent study by Gius (48) showed that the federal assault weapons ban was associated with higher rates of firearm homicides.

*Saturday night specials, United States.* Saturday night specials are inexpensive poor-quality guns commonly used in crime activity. In a cross-sectional study, Kleck and Patterson (7) found no associations between these laws and homicide rates. Webster et al. (77) studied the 1988 Maryland law banning these firearms in time-series analyses using 2 neighboring states as controls and NCHS data (1975–1998). These authors found the law was associated with a 6.8%–11.5% reduction in homicide rates when assuming a delayed effect model but not an immediate and constant model. Rosengart et al. (38) found no association of the law with reductions in firearm or all homicides rates when assuming an immediate and constant model. A reduction in suicide rates, but not in firearm suicide rates, was associated with the law.

*The 1988 Victoria state law, Australia.* Ozanne-Smith et al. (78) examined the Victoria law that tightened restrictions on semiautomatic long-arms and pump action guns, by comparing pre- versus posttrends of annual death rates in Victoria compared with other states in Australia. The law was associated with a 17.3% decrease in the rate of firearm deaths and lower rates of firearm suicides, but not with firearm homicides (78).

### Laws targeting sentences and punishment for gun offenders

Deutsch and Alt (79) examined the 1975 Bartley-Fox amendment to Massachusetts' gun control law that mandated a 1-year minimum prison term for carrying firearms without a license and a 2-year sentence for crimes committed while in possession of a firearm. Examining the following 6 months postimplementation, these authors found no association between the law and homicide rates. Similar results were observed by Berk et al. (80) and by Hay and McCleary (81) using UCR data up to 1976. Pierce and Bowers (82) using other cities as controls and data up to 1976 found a reduction of 55.7% in the rate of homicides, a reduction not observed in other control cities. In a posterior study, Deutsch (83) found the law to be associated with fewer homicides after adding more years of data.

Loftin and McDowall (84) examined the 1977 Michigan Felony Firearm Law, with 2-year mandatory sentences for felonies committed with or in possession of firearms. They found, in unadjusted autoregressive integrated moving average

models, that the law was associated with a 10.86% reduction in the number of firearm homicides in Detroit. These authors also observed similar results in 1 of 3 cities in Florida in regard to the state felony firearm law (3-year sentence for possessing a firearm while committing or attempting to commit a felony) (85) and also reductions in Pittsburgh and Philadelphia associated with legislation in Pennsylvania (5-year minimum sentence for violent crimes committed with firearms) (86). Fife and Abrams (87) also found similar results while examining the 1981 New Jersey “Graves Amendment” requiring minimum sentences of imprisonment without parole for possessing a firearm while committing a crime. O’Carroll et al. (88) found that the 1986 Detroit law (mandatory jail sentence for unlawfully carrying a firearm in public) was associated with higher rates of firearm indoor and nonfirearm homicides but not with firearm homicides or those committed outside.

Marvell and Moody (89) criticized previous studies for not adjusting models for confounders; in time-series analyses adjusting for state and year effects and state-level covariates, they found that laws requiring minimum sentences or additions to sentences for crimes committed with guns (1970–1993 data) were not associated with state-level homicide or firearm homicide rates; they confirmed only Deutsch’s findings for the Massachusetts law (83). La Valle (90), using data from 20 major cities (1970–2005 data), found that additional jail time was associated with reductions in firearm homicide rates, and minimum sentencing enhancements were associated with higher firearm homicide rates.

With regard to Project Exile from Richmond, Virginia (considered a sentence enhancement program as felons arrested for gun possession were brought to federal courts where sentences were more severe), Raphael and Ludwig (91) using UCR data (1994–1999) did not find strong evidence suggesting that the program was associated with reductions in firearm homicide rates once 1997 (a year with unusual high rates) was excluded. Rosenfeld et al. (92) added more years (1992–2001) and used adjusted multilevel models, and they observed a 22% yearly reduction in firearm homicides; however, this reduction was only marginal ( $P < 0.10$ ) when 1997 was excluded and replaced by the average of 1996 and 1998 values.

### Laws promoting voluntary rendition of firearms

Rosenfeld (93) found no association between firearm buyback programs implemented in St. Louis, Missouri (1991 and 1994) and firearm homicides. More recently, Phillips et al. (94) found that yearly firearm buyback programs implemented in Buffalo, New York, from 2007 to 2012 were not associated with reductions in firearm homicides. Leigh and Neill (95) evaluated the 1997 Australian gun buyback program and found no association between the program and firearm homicides but a reduction in suicide rates associated with the number of firearms that were bought back.

### Simultaneous implementation of laws targeting multiple elements of regulations

*US Gun Control Act of 1968.* This law restricted the sale of some handguns, blocked the importation of firearms not

meeting specific criteria, prohibited the sale of firearms to buyers without state identification, implemented licenses for firearm sellers and for owners, and banned the possession/purchasing of firearms by high-risk-group individuals (Table 3). Magaddino and Medoff (96), using data for the period 1947–1977 in structural models adjusted by state characteristics, found that the law was not associated with changes in homicide rates.

*District of Columbia 1976 law.* This law banned residents from owning automatic and semiautomatic firearms and handguns, placed stronger requirements for home firearm storage, and required registration of all firearms. Loftin et al. (97), using NCHS data (1968–1987) from the District of Columbia and adjacent metropolitan areas of Maryland and Virginia, found an abrupt reduction in homicide and suicide rates with no similar changes in control areas. Similar results for suicides were found by McDowall et al. (98) comparing the District of Columbia with Boston, Massachusetts, Memphis, Tennessee, and Baltimore, Maryland. Britt et al. (99, 100) questioned the selection of controls in the study by Loftin et al. (97), given the differences in homicide rates in the pre-law period; using Baltimore as the control area, Britt et al. found that the law was not associated with abrupt or gradual changes in homicide rates (no estimates for the law-suicide rates association were reported).

*1996 Maryland Gun Violence Act.* This law set stronger regulations including background checks and registration of handguns sold by private gun owners, 1 handgun purchase per month, and greater authority given to police and judges to confiscate firearms from domestic violence offenders. Webster et al. (77) examined the law in models adjusted for sociodemographics and trends in neighboring states (1975–1998 NCHS data) and found that the law was associated with reductions (from 10.3% to 11.4%) in firearm homicide rates in Maryland, assuming an immediate or delayed start, and constant/gradual effects.

*Canadian firearm-related bills.* Table 3 contains a summary of the 3 Canadian firearm bills. Regarding the variability in homicides rates, Leenaars and Lester (101) found that the 1977 bill C-51 was no longer associated with reductions in firearm homicide rates, as previously suggested (102, 103), after controlling for other socioeconomic indicators (101); however, reductions in homicide rates remained associated with the bill (101). Mauser and Holmes (104) found no associations between bill C-51 and all homicides in dummy models adjusted for covariates and time trends. Blais et al. (105) in models adjusted for potential confounders (1974–2004 data) found that bill C-51 was associated with reductions in firearm homicide rates. In this study, bill C-17 from 1991 was not associated with all or firearm homicides, but bill C-68 from 1995 was associated with lower firearm homicide rates.

More recently, Langmann (106) analyzed data from 1974 to 2008 using different modeling strategies and found no association of any of the 3 bills with firearm homicide rates and also no association between bills C-17 and C-68 and spousal firearm homicide rates (results for bill C-51 on this outcome were not provided). Using a similar approach, McPhedran and Mauser (107) found no associations between bill C-68 and firearm female homicides, but bill C-51 was associated with reductions in firearm female domestic homicides.

Studies on the association between the Canadian bills and suicide rates are also described. Unadjusted studies comparing pre- versus postlaw trend slopes showed that lower suicide (108) and firearm suicide (103, 109) rates were associated with bill C-51. Although the association with firearm suicides was diluted after adjusting for divorce and unemployment rates (102), additional analyses assessing trends in pre/post intervention periods and models adjusting for additional factors showed that bill C-51 reversed a prior steep increase in firearm suicides; further, although the bill was associated with lower firearm suicide rates in the population and among males and females (110), there was evidence of males switching to other methods.

Caron et al. (111), using Quebec, Canada, data (1987–2001), found that bill C-17 was not associated with changes in firearm suicide rates; an increment in the rates of suicides by hanging was observed among females. Gagné et al. (112) using Quebec data (1981–2006) in Joinpoint regressions found a breakpoint in 1996 indicating reductions in firearm suicides among males and individuals aged 15–34 years. Results from Poisson regressions showed reductions in suicide rates when the anticipated effect of bill C-17 was moved to 1995 (112). Similar results were identified by Cheung and Dewa (113) for firearm suicides after 1994. These 3 studies found that suicides due to hanging increased and that the rate of overall suicides did not change over time, which is suggestive of individuals switching to substitution methods.

Regarding unintentional firearm deaths, Leenaars and Lester (114) using national data (1969–1985) in models adjusted by unemployment and divorce rates, initially found bill C-51 was only marginally associated with lower death rates among males; later the authors found the bill was also associated with lower death rates in the entire population (102).

*The 1996 National Firearms Agreement (NFA) and the South Australia Firearms Act.* A summary of these laws is provided in Table 3. In regards to homicide rates, Ozanne-Smith et al. (78) examined the NFA using Victoria as a control group, given that this state had previously enacted firearm restrictions in 1988. The authors found a reduction (14%) in overall firearm death rates in states implementing NFA restrictions relative to Victoria (78). Another study by Chapman et al. (115), analyzed data from 1979 to 2003 and found evidence of an acceleration in the reduction in firearm deaths and all homicides after the passing of the law; although there was also a steeper reduction in firearm homicides, the trend ratio was not significant. In addition, no firearm mass shootings occurred in Australia after the NFA compared with 13 in the prelaw period (115). In contrast, Baker and McPhedran (116) compared observed versus predicted homicide rates after the NFA (1979–2004 data) in autoregressive integrated moving average models and found no association between the law and homicide rates, although the downward trend was observed to continue in the years after the law. Neill and Leigh (117) criticized Baker and McPhedran (116) for not using the log of death rates (which made expected rates become negative). Adjusting for new model specifications, they found a reduction in the firearm homicide rates associated with the NFA (117).

Lee and Suardi (118), using data from 1915 to 2004 and tests of unknown structural breaks, found no evidence suggesting

that the NFA was associated with reduction in homicides or suicide rates. In contrast, Chapman et al. (115) showed reductions in the rate of firearm and total suicide rates after the implementation of the NFA. Similar results were observed by Neill and Leigh (117) and by Baker and McPhedran (116) for firearm suicides. McPhedran and Baker (119), using an approach similar to that of Lee and Suardi (118), also identified a breakpoint in 1997 for firearm suicide rates but only for individuals aged 35–44 years (although no association was found in other models). Klieve et al. (120), examining data from the Queensland suicide register (1990–2004) and national data (1968–2004), found that the NFA was associated with negative trends in firearm suicide rates at the national level, but not with suicides among males in Queensland.

In regard to the 1977 South Australia Firearms Act, Snowdon and Harris (121) using data from Australian states (1968–1989) observed that the law was associated with lower rates of firearm suicides.

Finally, in regard to unintentional firearm death rates, Baker and McPhedran (116) and Chapman et al. (115) showed an increment in the rate of unintentional firearm deaths associated with the NFA (115), although they conclude that rates can be greatly affected by small changes in the number of annual cases given that unintentional firearm deaths are rare events.

*The Estatuto do Desarmamento in Brazil.* This law tightened restrictions on the possession of firearms and ammunition, implemented requirements for the registration of owned firearms, increased firearm costs, and established stronger penalties for illegal trafficking of firearms (Table 3). Marinho de Souza et al. (122), using time-series models (1996–2004 data) found that observed deaths were lower than predicted ones in the next 6 postlaw months.

*The 1997 Austrian firearm law.* This law placed restrictions for some firearms (including handguns and semiautomatics) and mandated background checks, minimum age requirements for purchases, safer firearm storage regulations, and waiting periods (Table 3). Kapusta et al. (123), using data from 1985 to 2005, found that the law was associated with reductions in firearm homicide (percent change in trends in pre/postlaw periods = -4.8) and firearm suicide (percent change = -9.9) rates in models adjusted for unemployment and alcohol consumption. Moreover, Niederkrotenthaler et al. (124) found that the law was associated with a long-term reduction in the rate of firearm suicides and the proportion of firearm suicides among adolescents (aged 10–19 years).

*The New Zealand Amendment to the Arms Act.* The law included bans on certain firearms, licensing for dealers and firearm owners that required passing training tests, police assessments of applicant and applicant's home, and interviews with family members. Beautrais et al. (125), using Poisson models and interrupted time-series analyses (1985–2002 data), found that the amendment was associated with reductions in the rate of firearm suicides among those aged 15–24 and 25 years or older, but not with reductions in all suicides.

*South Africa's Firearms Control Act.* This law banned certain firearms (including automatic guns), required an additional license per each gun owned and passing training tests to obtain licenses, increased age requirements for possession/purchase of firearms, and mandated background checks

(Table 3). Matzopoulos et al. (126) evaluated the association between the Act and changes in homicide rates in 5 major cities (2001–2005 data). Results showed a decreasing trend (13.6% per year) for firearm homicides through the implementation of the program and until 1 year after the law was fully implemented. Reductions in nonfirearm homicides were also observed, although not as pronounced as the ones observed for firearm homicides.

#### **Additional studies comparing states/cities with a classification based on degrees of firearm law strictness**

In regard to homicide rates, studies from the 1960s found little evidence of laws affecting homicide rates. Geisel et al. (127) compared states and major cities (1960–1965 data) and found that stricter laws were not associated with homicide rates. Magaddino and Medoff (96) and others (128–130) examined state and federal laws (requirements for sales and purchases) using data from 1960 and 1970, and they observed that associations between laws and homicide rates vanished after controlling for sociodemographic factors. A study by Seitz (131) (1967 data) showed that states with carrying and purchasing prohibitions had lower homicide rates among whites. Recent studies found that states/cities with stricter laws had lower rates of homicides (132), firearm deaths (133–135), and firearm injuries (136). Fleegler et al. (137), using a legislative strength score, found that states with scores in the highest quartile (more restrictive) compared with those in the lowest quartile had lower rates of firearm homicides.

In regard to variations in suicide rates, Geisel et al. (127) and other authors (129, 138–141) reported that stricter laws were associated with lower rates of suicides and unintentional death rates; however, other authors described that these associations vanished when models were adjusted for confounders (128, 130). Boor and Bair (142) (1985 data) found that stricter firearm laws were associated with reductions in suicide rates. Sloan et al. (143) while comparing 2 cities also found similar results for firearm suicides. In addition, Conner and Zhong (144) classified states according to strictness (1999–2000 data) and found lower suicide rates among males and females in states with stricter laws. Fleegler et al. (137) also identified lower firearm suicides in states in the highest quartile (most strict).

#### **CONCLUSIONS**

In a comprehensive review of firearm-control legislation worldwide, we identified a range of studies examining the association between firearm-related laws and firearm deaths. Three general observations emerge from this analysis: 1) The simultaneous implementation of laws targeting multiple elements of firearms regulations reduced firearm-related deaths in certain countries; 2) some specific restrictions on purchase, access, and use of firearms are associated with reductions in firearm deaths; 3) challenges in ecological design and the execution of studies limit the confidence in study findings and the conclusions that can be derived from them.

A variety of longitudinal studies describe the association between the simultaneous implementation of laws targeting multiple elements of regulations and firearm deaths. Despite

their limitations, specifically on the identification of which laws are more likely to be effective, these studies inform on the potential synergistic effects, or the aggregated individual effects of multiple laws, when they are simultaneously implemented within a narrow time window. The Australian NFA provides a good illustration of this. Following the implementation of the NFA, a decline in firearm deaths and firearm suicides, as well as an absence of mass shootings (78, 115, 117, 120), occurred. We found similar findings in other studies examining legislation targeting multiple elements of regulations in other countries (122–126), although, except in the case of Austria, findings have not been replicated. In Canada, although there has been a continuous downward trend in firearm death rates over time and legislation including background checks has been associated with fewer female firearm homicides, evidence of the association between these laws and overall homicides is mixed. Moreover, studies from Canada, New Zealand, and Australia (at least for the first post-NFA years) show that observed reductions in firearm suicides, after the implementation of these laws, were compensated by substitution methods that resulted in no significant changes in overall suicide rates.

There is also compelling evidence of specific laws being associated with reductions in the rate of firearm deaths. Studies on background checks suggest that the quality of systems used to review applicants, in terms of the access to local and federal information on mental health conditions and criminal and domestic violence history, is a critical component of these laws. However, in some longitudinal studies, little attention is given to whether states conducted local checks and how results would vary after adjusting models for this. US studies examining more detailed aspects of background check laws describe how requiring checks on restraining orders is associated with reductions in intimate partner female firearm homicides, and how checking local mental health facility records is linked to fewer firearm suicides. Regarding child access prevention laws, most studies in the United States show that additional laws allowing for felony prosecution of offenders are associated with greater reductions in unintentional deaths among children. In addition, most studies show that relaxing firearm restrictions, as in the case of “stand your ground” laws or the repealing of existing permit laws, may increase the rate of firearm homicides. We also found international evidence suggesting that, in a particular setting with high rates of homicides, banning the carrying of firearms on sensitive days along with police enforcement can be an effective strategy to reduce homicide rates.

In contrast, evidence suggests that laws restricting the sales of certain firearms are not associated with variations in all or firearm homicides. In this regard, it is possible that because of the fact that studies examine short periods after the laws are implemented, studies may not be able to identify a significant association, as the effects of these laws are more likely to be gradual and delayed given the already high rate of firearms ownership and the availability of firearms in secondary markets. A similar situation may occur for studies with short postlaw periods examining laws targeting sentences for gun offenders, as described for studies on the 1975 Massachusetts’ law. In addition, for laws targeting sentences, variations in the restrictions and the types of sentence in states, and also

the interactions with other factors, such as law enforcement and limitations in jail space, may explain the different results across regions and studies.

One potential problem of studies on firearms laws is the way in which the author's affiliations and personal interests bias study results and influence what is to be published. This can be particularly problematic when researchers are funded by for-or-against firearms groups and when these organizations have control of what material is publishable and what is not, and also when researchers purposely select to present only the results that match their interests. In this review, we have avoided making statements on sources of funding or on affiliations of authors, although we acknowledge that this is an important problem that may distort the general information that could be obtained from this review, and that may contribute to publication bias.

In addition, the studies reviewed here may suffer from validity problems that are common in observational ecological studies. In this regard, cross-sectional studies are of least design suitability (145), and although useful for hypothesis generation, they offer little information on which laws are more likely to work in certain settings. Alternatively, longitudinal studies, especially those examining changes in outcomes before and after the legislation and those including control groups, offer stronger evidence. Longitudinal studies looking at local policy changes, although less generalizable, may provide more precise information on factors necessary for interventions to work compared with those using national aggregated data. However, we observe that incomplete or missing data or problems in quality of the data challenge the evaluation of laws at local levels. Additional concerns of validity, even in longitudinal designs, include the lack of robustness of findings to modeling specifications, such as regarding the use of more years of data or moving the expected point of the intervention effect. Also, particular challenges in study execution include specifications that control for potential confounders that can also be mediators (e.g., firearm ownership). Researchers adjusting for these variables without acknowledging the presence of mediating effects can wrongly conclude that these laws are not associated with the outcomes.

While identifying the limitations of designs and the execution of studies reviewed here, we also identified opportunities for future research. First, studies focusing on the association between the relaxation of firearms laws, such as Missouri's repeal of permits law and the "stand your ground" law, and firearm-related deaths provide an alternative angle to evaluate firearm legislation. Research in this direction may be able to identify more abrupt changes in firearm mortality compared with research on the implementation of new laws, which in theory would have more gradual and delayed effects (67). Second, limited availability and quality of injury data have driven most research to focus on firearm deaths, the most extreme outcome. Better data to assess changes in firearm injuries at both the national and state levels could improve our knowledge on the consequences of firearm laws with a broader scope. Third, we found that few studies have examined how these laws are associated with outcomes among particular ethnic/racial or lower socioeconomic groups; focusing on subgroup outcomes would help to identify which

laws may be most beneficial to those at greater risk. Fourth, research is needed to understand how the enactment or repeal of firearms laws is associated with changes in social attitudes, norms, and behaviors and how this in turn is associated with firearm deaths. Fifth, there is little research using complex systems approaches to identify or predict variations in firearm deaths when single or multiple laws are implemented and how the magnitude of associations would vary in the presence of other factors (e.g., enforcement). As these methods evolve, they may become an avenue to explore the benefits and disadvantages associated with firearms laws and other alternatives in different population contexts. There are also unanswered questions on whether new alternatives, not directly targeting firearm rights, such as increments in firearm taxation, safer manufacturing of firearms, or background checks for all private sales, can be effective in reducing firearm-related death rates.

To conclude, we have provided an overview of national and international studies on the association between firearm-related laws and firearm injuries/deaths. High-quality research overcoming limitations of existing studies in this field would lead to a better understanding of what interventions are more likely to work given local contexts. This information is key for policy development aiming at reducing the burden posed to populations worldwide by violent and unintentional firearm injuries.

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