J Behav Med (2019) 42:741–762
https://doi.org/10.1007/s10865-019-00063-y

The association of firearm laws with firearm outcomes among children and adolescents: a scoping review

April M. Zeoli[1,2] · Jason Goldstick[2,3] · Amanda Mauri[2,4] · Mikaela Wallin[1,2] · Monika Goyal[2,5] · Rebecca Cunningham[2,3] · For the FACTS Consortium[2]

Received: December 1, 2018 / Accepted: May 21, 2019 / Published online: August 1, 2019

Abstract We conducted a scoping review to determine the current state of knowledge and areas for advancements in research on the association of firearm laws with child and adolescent firearm-related outcomes. We queried Scopus, EMBASE, Pubmed, and CJ Abstracts for English language original empirical research articles on policies affecting child and adolescent firearm-related outcomes published between January 1, 1985 and July 1, 2018. Data were abstracted, and methodologic quality assessed. Twenty articles met inclusion criteria. Among the policies studied were child access prevention laws (12 studies) and minimum age restrictions for firearm purchase and possession (4 studies). Outside of child access prevention laws, which are associated with reductions in child and adolescent unintentional and firearm suicide deaths, there is, at best, equivocal evidence of policy effects. This area is understudied, particularly in regard to nonfatal firearm injuries, for which the lack of a national surveillance system hampers research efforts. Further rigorous firearm policy evaluations are needed.

Keywords Firearm policy · Homicide · Suicide · Scoping review

Introduction

Fatal and nonfatal firearm injuries in children are an urgent concern in American society. The rate of firearm-related deaths of those aged 0–17 years has steadily increased in recent years from a low of 1.71 per 100,000 firearm deaths in 2013, up to 2.22 per 100,000 in 2016 (Centers for Disease Control and Prevention, 2018), and is currently the 2nd leading cause of child and adolescent death in the United States (Cunningham et al., 2018). Furthermore, recent mass shooting events that occurred at primary and secondary schools have thrust the issue of preventing firearm deaths among children to the forefront.

In the United States, federal and state law are mechanisms through which we seek to reduce the burden of firearm injuries and deaths, be they through unintentional, interpersonal, or self-directed violence. In recent years, there have been multiple reviews of studies of the association of firearm policies on firearm outcomes (see, for example, Santaella-Tenorio et al., 2016). Results of these reviews broadly suggest that some firearm policies, such as requiring criminal background checks for firearm sales, are associated with reductions in firearm deaths, but, to our knowledge, none have focused on child and adolescent firearm outcomes.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10865-019-00063-y) contains supplementary material, which is available to authorized users.

✉ April M. Zeoli
zeoli@msu.edu

[1] School of Criminal Justice, Michigan State University, 655 Auditorium Road, East Lansing, MI 48824, USA

[2] Firearm Safety Among Children and Teens Consortium, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA

[3] Department of Emergency Medicine, University of Michigan School of Medicine, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA

[4] Department of Health Management and Policy, University of Michigan School of Public Health, Ann Arbor, MI, USA

[5] Children's National Medical Center, The George Washington University, Washington, DC, USA

The nature of firearm-related injury differs across the lifespan. First, the mechanism of firearm injury varies by age. For example, children under the age of 10 years rarely commit suicide by any method, however firearm homicide and unintentional firearm deaths are both among the top 10 causes of injury deaths for this age group in the US (Centers for Disease Control and Prevention, 2018). Furthermore, both firearm homicide and firearm suicide become much more prevalent for those 10 years of age and older (Centers for Disease Control and Prevention, 2018). Second, circumstances behind firearm deaths also vary by age. For example, while only 9% of firearm homicides among those under age 18 are related to intimate partner violence, when restricting to ages 0–12, 31% of firearm homicides are related to intimate partner violence (Fowler et al., 2017); this difference was explained by surges in other circumstances of homicide, such as gang-related and drug-involved homicides, among those ages 13–17 (Fowler et al., 2017). The percentage of children killed in ways related to intimate partner violence suggest that firearm restrictions for domestic violence offenders may have the potential to safeguard children in addition to intimate partners. Similarly, unintentional firearm deaths and firearm suicides may be decreased by increasing the difficulty children have gaining access to guns, such as through child access prevention (CAP) laws. More generally, the age-specific epidemiology of firearm violence calls for a more nuanced approach to policy-based prevention efforts that are age-specific.

Policy is a tool designed to impact population-level change and outcomes, and has the potential to drive behavioral change and reduce exposure to harm. Stakeholders interested in reducing the burden of firearm injuries to children and adolescents need empirical evidence on the impact of policies to know how to focus their efforts. This scoping review examines existing empirical research that analyzes the association of federal and state firearm laws with childhood firearm outcomes, including gun deaths and injuries, to determine what is known about their effectiveness in relation to childhood and adolescent outcomes and to highlight gaps in the literature. Recognizing that studies focusing on the population at large, without age-specificity, are not designed to detect differences in child outcomes and may miss obscure yet important associations, we focused specifically on studies evaluating effects on child and adolescent firearm outcomes.

Methods

Search strategy and eligibility criteria

We conducted this scoping review with the assistance of an Informationist at the Taubman Health Sciences Library at the University of Michigan. This review comprehensively searched the following four databases for relevant articles: PubMed, Scopus, EMBASE, and CJ Abstracts. The initial search was created in PubMed and searches of other databases were translations of that search. Forward and ancestry citation searches of included articles were conducted in Scopus to gather any articles that may have been missed during the initial search. Search terms used were a combination of Medical Subject Headings (MeSH) and free text terms restricted to search titles and abstracts (tiab) of articles. Search terms included variations of the words gun, legislation, homicide, suicide, death, injuries, and children. For a full list of search terms see Web Appendix 1. The search was restricted to English language articles published between January 1985 and July 2018.

To be included in the scoping review, the English-language original empirical research article had to test the association of a local, state, or federal policy on at least one childhood firearm outcome (defined below) in the United States. We did not limit our review to policies specific to firearms due to the possibility that a violence prevention, or more general, policy may have been tested for an impact on firearm violence. However, the original empirical research study must have had at least one of the following as a *dependent* variable: childhood fatal or nonfatal firearm injury or victimization, firearm offending, firearm possession or access, or gun carriage; or parental gun storage. The exception to this, however, was that we decided, a priori, to include studies with the dependent variables of total suicide or total homicide only if the paper estimated the association of firearm-specific policies with these outcomes. This review focuses on policies present in the United States; as such, research conducted outside of the US was excluded.

Our initial inclusion criteria specified that outcomes must have been measured in samples that included children aged 0 through 17 years old (< 18). However, as we moved through the process of including articles, we refined this criterion to be that outcomes must have been measured in a sample that included those aged 17 and under, but we did not exclude articles if they studied adolescents aged 18–20 years as long as they included ages under 18. We did not limit the articles to those that studied groups solely comprised of those aged 17 and younger, because we believed that the information gained from including them in this review outweighed the potential bias as there are so few articles focused on children and adolescents. Research

conducted solely with populations aged 18 and above were automatically excluded.

Articles were excluded if they were book chapters or if full text was not available. Review articles, editorials, letters to the editors, and research that had direct policy implications, but did not otherwise meet our inclusion criteria, were excluded. We also excluded research on non-powder firearms, such as bb guns, paintball guns, and airsoft guns. Studies that analyzed household gun ownership as a dependent variable were excluded unless they tested a dependent variable measuring child access to or parental safe storage of guns.

Study selection

Citation information and abstracts for all articles identified during the initial keyword search were downloaded into an EndNote database and exported into the web-based program Rayyan (Ouzzani et al., 2016) for the title and abstract review. Two expert reviewers independently reviewed the same 100 articles to pilot the title and abstract review process. Consensus was achieved between the two reviewers, and they trained student reviewers on the inclusion protocol and process. Two individuals, who were blind to each other's conclusions, reviewed each title and abstract for inclusion independently. The independent reviewers erred on the side of inclusion, particularly when the age of the study population was unclear from the abstract. The primary author reviewed all titles and abstracts for which there was lack of consensus and presented them to the authorship team until consensus was reached.

The primary author reviewed each article's abstract and, when additional information was needed, full text to verify that it met inclusion criteria. Articles that did not meet inclusion criteria (often due to not studying the population under age 18), were removed at this stage. Once the inclusion list was verified, the forward and ancestry citation searches were conducted and the inclusion process repeated for the small number of non-duplicate articles newly identified.

Data abstraction, synthesis, and analysis

Data were extracted from each article using a standardized data chart that captured the following elements: policies under study; study design; population sample and setting; primary and secondary outcome measures; main study findings; and suitability of the study design. We did not report results that were not directly relevant to our review (e.g., any results applying only to adult populations). After the initial data abstraction, the first author grouped articles by which state and federal policies were studied (no papers about local level policies met inclusion criteria), with many articles appearing in multiple groups due to testing multiple laws. The policies studied were (1) CAP laws; (2) minimum age restrictions for purchase or possession of a gun; (3) permit-to-purchase laws and background check system implementation (which we grouped together as they are both related to); (4) stand your ground laws; and (5) junk gun bans. These laws are defined in Table 1. A sixth category was developed to reflect the multiple studies that examined a state's overall legislative strength regarding firearms via a score measuring multiple laws.

To assess methodological rigor of the included studies, we broadly modified the "suitability of study design for assessing effectiveness" schema presented by Briss and colleagues for the *Guide to Community Preventive Services* (2000), which has been used to assess study rigor in previous reviews of firearm policy research (Santaella-Tenorio et al., 2016). The categorization of greatest suitability was reserved for studies that took serial cross-sectional measurements across multiple jurisdictions (effectively, jurisdiction-level time series), usually states, to make use of both within- and between-jurisdiction variability in policies studied. Additionally, we required that studies meeting the "greatest" suitability criteria must account for unmeasured confounding across jurisdictions or years via jurisdiction-level and temporal fixed effects. Moderate suitability studies were those that analyzed serial cross-sectional measurements across multiple jurisdictions but failed to account for unmeasured confounding by jurisdiction or time. Least suitability studies were those based on single cross-sectional measurements, in one or multiple jurisdictions. See Table 2 for our modified suitability criteria.

Articles were divided among authors, and each article underwent a primary and secondary data abstraction and suitability of the study design assessment. The secondary reviewer had access to the data charting of the primary reviewer and verified accuracy of the information or edited the data charting, as needed. After this process was complete, each article and its data charting and suitability assessment was verified a final time by JG.

Results

Sample characteristics

Including the articles identified during forward and ancestry citation searches, the search strategy identified a total of 4173 articles (see Fig. 1). Of these, 1283 were duplicates and removed prior to screening for inclusion. 2890 articles were reviewed for title and abstract inclusion and reviewers found that 72 articles were potentially eligible for the review. Finally, 20 articles met eligibility

Table 1 Policy descriptions for laws studied in included articles

Policy name	Description
Child access prevention (CAP) laws	Impose criminal liability on adults who either negligently store or recklessly provide children access to their guns. Variations in laws between states include whether adults can be charged with misdemeanor or felony crimes; whether someone can be criminally liable for negligent storage of a gun or if they must recklessly provide the gun to a child; and the age of the child who may have access to the gun (ranging from under 14 to under 18)
Minimum age restrictions	Mandate a minimum age (usually 18 or 21) for purchase of a gun and, separately, for possession of a gun
Purchase-related laws	Permit-to-purchase laws require a prospective gun purchaser to obtain a license to purchase a gun through local officials after a background check is conducted. This generally applies to both private gun sales and sales through a licensed gun dealer
	Background check systems are those systems in which records disqualifying someone from gun purchase or kept
Junk gun bans	Limit the sale and possession of inexpensive, low quality firearms
States' firearm legislation strength	Measures how many gun safety laws a state has

Table 2 Modified suitability of study design for assessing effectiveness

Suitability	Attributes
Greatest	(1) Serial cross-sectional measurements across jurisdictions where there is both within-state and between-state variability in policies studied
	(2) Models contain jurisdiction-level and temporal fixed effects to account for unmeasured confounding
Moderate	Meets attribute (1) above, but not attribute (2)
Least	Does not meet attribute (1) above

Modified from Briss et al. (2000)

criteria and were included in the scoping review. Information on these studies can be found in Table 3.

Each policy category specified above was represented in at least one of the 20 articles. Twelve studies included a measure of a CAP law. Four studies analyzed a minimum age restriction firearm law. Two tested a law related to firearm purchase beyond minimum age. Only one study was included in the policy categories of stand your ground laws and junk gun bans. Eight studies measured the association of a state's firearm legislation strength score with child and adolescent firearm outcomes. Six studies were included in more than one policy category.

Eleven studies were judged to be of least suitability, while nine were of greatest suitability. No studies met our criteria for moderate suitability. The remainder of the results section is organized by the policy under study (CAP laws, minimum age restriction laws, purchase laws, junk gun bans, and states' firearm legislation strength). Within each policy section, the results are organized by the outcome under study.

Child access prevention laws

By far the most commonly studied policy with regard to child and adolescent outcomes, eleven articles estimated the effects of CAP laws on child and adolescent firearm outcomes and one article investigated whether these laws were associated with parental safe gun storage. Seven studies were of the greatest suitability while five were of the least suitability.

Unintentional firearm mortality

Six studies, five of greatest suitability and one of least suitability, have focused on the relationship between CAP laws and unintentional firearm deaths, with equivocal findings. The study judged to be of least suitability by Ruddell and Mays (2004) failed to find a significant difference in *unintentional* firearm deaths among children between states with versus states without CAP laws. Additionally, neither Gius (2015) nor Lott and Whitley (2001), both studies of the greatest suitability, found evidence of an association between these laws and unintentional child and adolescent firearm deaths. Both these studies used a population aged up to 19 years to test for a law effect, while the oldest age for which CAP laws impose criminal liability varies from 14 to 17 years, depending upon the state.

Three studies of the greatest suitability suggest that CAP laws are associated with reductions in unintentional firearm deaths of those under age 15 years (Cummings et al., 1997; Hepburn et al., 2006; Webster & Starnes, 2000), but this effect appears to vary based on the level of criminal liability conferred by the law. Specifically, relative to states

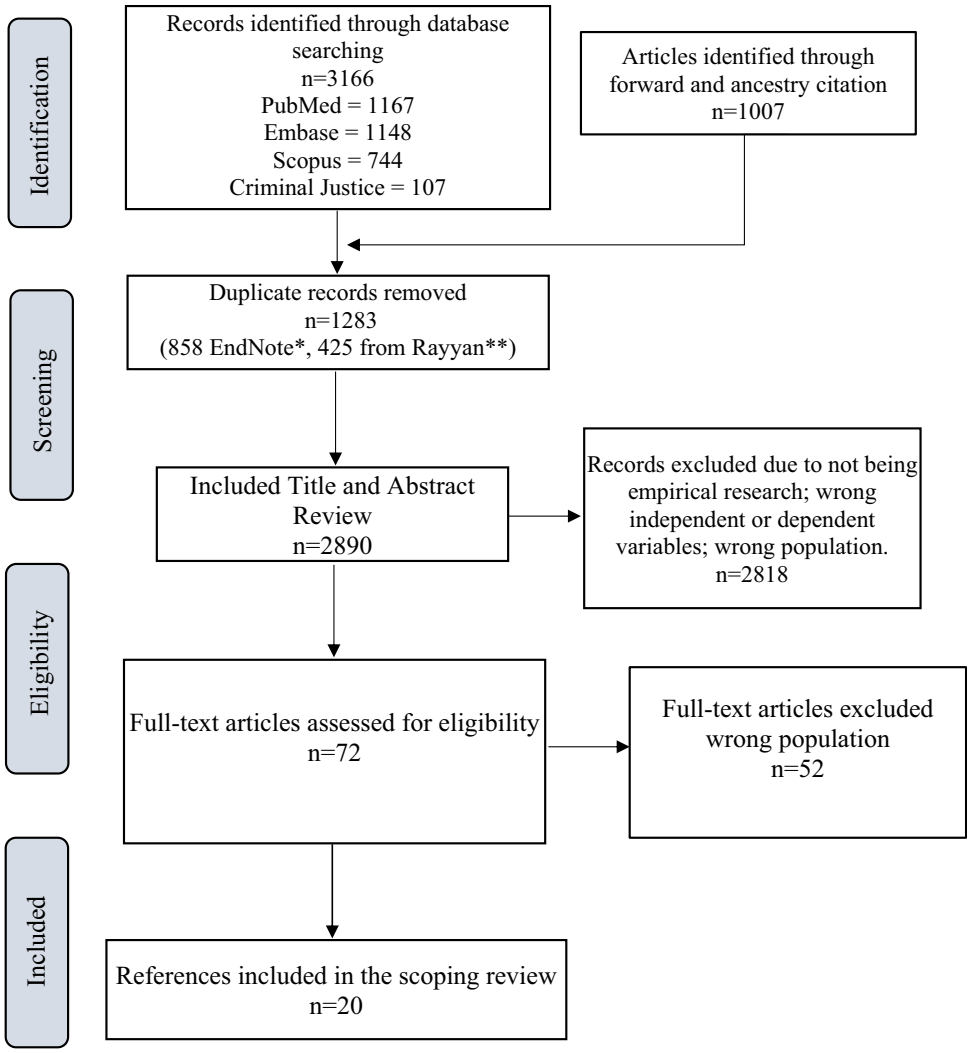

Fig. 1 PRISMA flow diagram

*Endnote: A commercial reference management software package.

**Rayyan: A web application to help with reviewing articles.

without these laws, states with felony CAP laws had larger reductions in unintentional firearm death than the reductions associated with misdemeanor CAP laws, or CAP laws irrespective of penalty (Hepburn et al., 2006; Webster & Starnes, 2000; Cummings et al., 1997). In fact, analyses of misdemeanor CAP laws suggested there was no change in youth unintentional firearm deaths (Hepburn et al., 2006; Webster & Starnes, 2000; Cummings et al., 1997). The between-state heterogeneity in CAP law provisions, which evidently has an impact, may partially explain the inconsistent findings. Taken together, and considering important limitations, the literature provides strong evidence that CAP laws are associated with reductions in unintentional firearm mortality among children and adolescents.

Homicide and suicide mortality

Evidence is mixed on the effect of CAP laws on child and adolescent homicide and suicide. Three studies, all meeting the greatest suitability criteria, studied CAP laws and suicide. Among those, two showed associations between the laws and reduced firearm suicide (Gius, 2015; Webster et al., 2004), while one did not (Cummings et al., 1997). Unlike the unintentional firearm injury results, there was no evidence that severity of the penalty under the law modified their associations with homicide or suicide; specifically Webster et al. (2004) found that whether felony or misdemeanor crimes could be charged under a CAP law did not substantially change the estimated association of all

Table 3 Characteristics and findings of included firearm policy articles

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Beaver (1993)	Saturday night specials	Before-after unit: state-year	Ages: 0–16 years Setting: Maryland, 1979–1992	(1) Maryland Mortality File (Bureau of Vital Statistics) and (2) Office of the Chief Medical Examiner records	Firearm deaths	The average number of pediatric firearm deaths in Maryland increased from 14 to 22 per year after the Saturday night special ban	Least
Cummings (1997)	CAP laws	Time series study with comparison groups. Unit: state-year	Ages: 0–14 years Setting: 50 US states and Washington DC, 1979–1994	Mortality files of the National Center for Health Statistics	Unintentional firearm deaths, firearm suicides, and firearm homicides	Among youth age 0–14, adjusted incidence of unintentional firearm deaths were lower after CAP law introduction (IRR 0.77, 95% CI 0.63–0.94); reductions in gun suicides (IRR 0.81, 95% CI 0.66–1.01) and gun homicides (IRR 0.89, 95% CI 0.76–1.05) were not statistically significant; non-firearm suicides and homicides were unchanged following enactment of the laws. In states that allowed felony prosecutions, the reduction in unintentional mortality was significant (IRR 0.59, 95% CI 0.45–0.77); in states with only misdemeanor penalties, there was no association (IRR 1.14, 95% CI 0.85, 1.12)	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
DeSimone (2013)	CAP laws	Time series study with comparison groups. Unit: state-year	Ages: 0–17 years Setting: Hospitals in 11 US states (AZ, CA, CO, FL, IL, IA, MA, NJ, PA, WA, WI), 1988–2003	Agency for Healthcare Research and Quality's Nationwide Inpatient Sample	Self-inflicted, unintentional, assault-related, undetermined intent, and total nonfatal firearm injuries resulting in hospitalization	Among youth age 0–17, CAP laws (negligent storage or reckless provision) were associated with a decrease in the rate of total firearm injury not including self-inflicted (RR 0.78), self-inflicted (RR 0.35), and undetermined firearm (RR 0.40), but associations with firearm assault and unintentional firearm injury were not significant (at level $\alpha = 0.05$) Results remained qualitatively similar when restricting focus to only states with CAP laws relating to negligent storage	Greatest
Gius (2015)	CAP laws; state and federal minimum age possession restrictions	Time series study with comparison groups. Unit: state-year	Ages: 0–19 years Setting: 50 US states, 1981–2010	CDC WISQARS	Firearm suicide and unintentional firearm deaths	With regard to youth suicide—the adjusted effect of CAP laws on the rate was a reduction of 0.218 suicides per 100 k, and the adjusted effect of a federal minimum age law was a reduction of 1.24 suicides per 100 k (both $p < 0.001$); there was no significant effect of the state minimum age law With regard to unintentional death—the adjusted effect of a federal minimum age law was a reduction of 0.47 deaths per 100 k ($p < 0.001$); there was no significant effect of the state minimum age laws or CAP laws	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Hamilton (2017)	CAP laws	Cross-sectional. Unit: state	Ages: 0–17 years Setting: Participating hospitals in 44 US states, pooled across 2006–2009	Healthcare Cost and Utilization Project's Kids' Inpatient Database	Self-inflicted, unintentional, assault-related, and total nonfatal firearm injuries resulting in hospitalizations	Relative to states with no CAP laws, states with strong CAP laws (criminal liability for negligent storage) had lower total (IRR 0.70, 95% CI 0.52–0.93), self-inflicted (IRR 0.46: 95% CI 0.26–0.79), and unintentional (IRR 0.56, 95% CI 0.43–0.74), but not assault (0.77, 95% CI 0.54–1.09), firearm injuries Relative to states with no CAP laws, states with weak CAP laws (criminal liability for provision of firearms to minors) had higher total (IRR 1.79, 95% CI 1.31–2.44), self-inflicted (IRR 1.82, 95% CI 1.03–3.23), unintentional (1.71, 95% CI 1.29–2.25), and assault (1.78, 95% CI 1.19–2.67) firearm injuries	Least
Hepburn (2006)	CAP laws	Time series study with comparison groups. Unit: state-year.	Ages: 0–14 years Setting: 50 US states, 1979–2000	CDC WONDER	Unintentional firearm deaths	CAP laws overall were associated with reduced unintentional firearm deaths among children (RR 0.78, 95% CI 0.61, 0.99). Relative to states without CAP laws, felony CAP laws (RR 0.64, 95% CI 0.46, 0.89), but not misdemeanor CAP laws (RR 0.93, 95CI: 0.76, 1.13), were associated with reduced unintentional firearm deaths. When Florida or California (both felony CAP law states) was excluded from the analysis, the statistical significance was lost	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Lee (2013)	CAP laws; stand your ground (SYG) laws	Cross-sectional. Unit: Individual	Ages: 0–20 years Setting: Participating hospitals in 44 US states, pooled across 2006–2009	The Healthcare Cost and Utilization Project's Kids' Inpatient Database	Self-inflicted, unintentional, assault-related, and total firearm injuries resulting in hospitalizations	Without covariate adjustment, SYG laws increased the odds that a given injury was a firearm injury (OR 1.15, 95% CI 1.11, 1.19). This finding applied to firearm assault injuries (OR 1.10, 95% CI 1.05, 1.14), unintentional firearm injuries (OR 1.28, 95% CI 1.20, 1.37), and self-inflicted firearm injuries (OR 1.66, 95% CI 1.35, 2.04) Without covariate adjustment, CAP laws increased the odds that a given injury was a firearm injury (OR 1.21, 95% CI 1.18, 1.25). This finding applied to firearm assault injuries (OR 1.31, 95% CI 1.27, 1.35), but not unintentional firearm injuries (OR 1.04, 95% CI 0.98, 1.10), or self-inflicted firearm injuries (OR 0.86, 95% CI 0.73, 1.01). When restricted to only those $\leq$ 12 years old, those from states with CAP laws had lower risk of a given risk being an accidental firearm injury (OR 0.74, 95% CI 0.66, 0.83) or a firearm suicide-related injury (OR 0.23, 95% CI 0.09, 0.58) In adjusted analysis, both CAP laws (OR 1.27, 95% CI 1.23, 1.32) and SYG laws (OR 1.20, 95% CI 1.15, 1.24) increased the odds a given injury was firearm-related	Least

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Lott (2001)	CAP laws	Time series study with comparison groups. Unit: state-year	Ages: 1–19 years Setting: 50 US states, 1977–1996	Authors did not disclose the data source or describe it in any detail	Unintentional firearm deaths and firearm suicides	CAP laws were not associated with accidental gun deaths or suicide deaths among children in any of the age groups studied (< 5, 5–9, 10–14, 15–19 for unintentional; < 15, 15–19 for suicide)	Greatest[a]
Marvell (2001)	State minimum age gun possession laws	Time series study with comparison groups. Unit: state-year	Ages: 15–19 and 14–17 years Setting: 37 US states	CDC mortality data 1979–1998; Bureau of Justice Statistics, 1976–1999	Firearm homicide victimization and offending, Firearm suicides	Minimum age gun possession laws had no effect on gun homicide victimization among age 15–19, including cases where the law was instituted early ($\beta = 0.00$, $p = 0.99$), those that instituted the law in 1994 ($\beta = 1.72$, $p = 0.09$), and with regard to only the federal law ($\beta = -0.05$, $p = 0.56$). Analogously, there were no effects for any of the three minimum age gun possession laws policies on gun suicides among age 15–19	Greatest
Murnan (2004)	22 state firearm laws grouped into five categories: (1) crime detection; (2) government control; (3) possession restriction; (4) safety; (5) sales restriction	Cross-sectional. Unit: state	Ages: 1–18 years Setting: 38 US states that participated in YRBS in 2001	CDC WISQARS 2000	Firearm deaths	Authors used forward selection to select predictors of firearm mortality; no policy variables were selected under this process, suggesting lack of association	Least

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Prickett (2014)	CAP laws; measure of state firearm legislation strength	Cross – sectional. Unit: individual	Ages: parents of 4-yr-old children Setting: US in 2005	Early Childhood Longitudinal Study	Three-level variable: (1) Does not own firearms; (2) owns firearms but store in locked cabinet; (3) owns firearms but does not store in locked cabinet	In adjusted analysis, CAP laws decreased the likelihood of locked firearms, relative to not owning firearms (AOR 0.59, 95% CI 0.44, 0.83), and increased the likelihood of having unlocked firearms, relative to locked (AOR 2.31, 95% CI 1.45, 3.69). CAP laws increased the likelihood of owning unlocked firearms, relative to not owning firearms, but that increase was not significant (AOR 1.39, 95% CI 0.92, 2.09). Legislative strength did not differentiate any pair of categories There were significant interactions between CAP laws and overall policy strength. When legislative strength was zero, CAP laws corresponded to increased likelihood of locked storage relative to both non-ownership (AOR 4.03, 95% CI 1.82, 8.89) and locked storage (AOR 5.14, 95% CI 2.15, 12.26). Each additional point of legislative strength decreased those AORs by 0.68 (95% CI 0.53, 0.87) and 0.74 (95% CI 0.56, 0.98), respectively	Least

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Resnick (2017)	Measure of state firearm legislation strength	Cross-sectional (three separate studies aggregating 5-year periods). Unit: state	Ages: 0–14 years (all mortality), and 0–18 years (suicide) Setting: 50 US states, 1999–2003, 2004–2008, and 2009–2013	CDC WISQARS	Firearm suicide, total firearm deaths	Age 0–14 firearm death rates were lower in Brady-grade "A-D" states versus Brady-graded "F" states in 2004–2008 (0.35 vs. 0.71, $p = 0.003$) and 2009–2013 (0.41 vs. 0.83, $p = 0.001$), but not 1999–2003 (0.75 vs. 1.35, $p = 0.06$) Age 0–18 firearm suicide rates were lower in Brady-grade "A–D" states versus Brady-graded "F" states in 2004–2008 (0.30 vs. 1.22, $p < 0.001$) and 2009–2013 (0.65 vs. 1.43, $p < 0.001$), but not 1999–2003 (1.12 vs. 2.03, $p = 0.06$) States where a majority of legislators received an "F" on the NRA scorecard in 2012 had fewer deaths than states with "A–D" NRA scorecards in 2012 with regard to age 0–14 overall firearm deaths (0.36 vs. 0.74, $p = 0.01$) and age 0–18 firearm suicides (0.41 vs. 1.31, $p < 0.001$)	Least
Rosengart et al. (2005)	State minimum age purchase and possession laws	Time series study with comparison groups. Unit: state-year.	Ages: 0–19 years Setting: 50 US states and Washington, DC in 1979–1998	National Center for Health Statistics Compressed Mortality Files	Firearm homicide, firearm suicide	Purchase restrictions for those under 21 were unassociated with firearm homicides (RR 0.92, 95% CI 0.80, 1.06) and suicides (RR 0.94, 95% CI 0.80, 1.06) among those under age 20 Possession restrictions for those under 21 were unassociated with firearm homicides (RR 0.91, 95% CI 0.72, 1.15) and suicides (RR 0.93, 95% CI 0.77, 1.12) among those under age 20	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Ruddell (2004)	CAP laws; background check strength; measure of state firearm legislation strength	Cross-sectional. Unit: state	Ages: 0–16 years Setting: 50 US states in 1996–2000	CDC WISQARS	Unintentional firearm deaths	CAP laws (b = − 0.02), background check strength (b = 0.00), and overall policy strength (b = 0.05) were unassociated with juvenile unintentional firearm mortality	Least
Safavi (2014)	Measure of state firearm legislation strength	Cross-sectional. Unit: state	Ages: 0–18 years Setting: Participating hospitals in 44 US states in 2009	Agency for Healthcare Research and Quality's Nationwide Inpatient Sample	Firearm injuries resulting in hospitalization	The mean firearm injury rate per 1000 trauma patients was lower (p = 0.001) in states with strict firearm laws (mean [SD]: SFL, 2.2 [1.6]) than in states without strict firearm laws (mean [SD]: SFL, 5.9 [5.6])	Least
Simonetti (2015)	CAP laws	Cross-sectional. Unit: state	Ages: 0–19 years Setting: 18 US states in 2010	Healthcare Cost and Utilization Project's State Inpatient Database and the State Emergency Department Databases	Self-inflicted, unintentional, assault-related, undetermined intent and total firearm injuries resulting in hospitalization or ED visits	States with strict CAP laws had lower rates of self-inflicted firearm injuries (IRR 0.52, 95% CI 0.34, 0.81) and unintentional firearm injuries (IRR 0.68, 95% CI 0.52, 0.91) than states with non-strict laws; there were no differences in assault-related firearm injuries (IRR 1.03, 95% CI 0.77, 1.37) or total injuries (IRR 0.79, 95% CI 0.60, 1.03)	Least

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Tashiro (2016)	Measure of state firearm legislation strength	Cross-sectional. Unit: Individual	Ages: 0–19 years Setting: Participating hospitals in up to 44 US states, pooled across 2000 to 2009	The Healthcare Cost and Utilization Project's Kids' Inpatient Database	As a fraction of total firearm-related admissions, mortality rates, and frequency of assault-related, unintentional, self-inflicted, and undetermined intent firearm injuries	One-to-one propensity score matching of admissions in lenient gun control states with those in strict states showed the in-hospital mortality rate was higher in lenient states than in strict states (7.5% vs. 6.5%, $p = 0.01$). In addition, in strict states, the assault rate was higher (75% vs. 54%, $p < 0.001$), the accidental injury rate was lower (17% vs. 31%, $p < 0.001$), and the undetermined (6% vs. 10%, $p < 0.001$) and self-inflicted (1.6% vs. 4.4%, $p < 0.001$) rates were lower, as a fraction of all firearm-related admissions	Least
Webster (2004)	State and federal minimum age purchase and possession laws; permit to purchase laws; CAP laws	Time series study with comparison groups. Unit: state-year.	Age: 14–17 years Setting: 50 US states, 1976–2001	National Center for Health Statistics Compressed Mortality Files	Firearm suicides	CAP laws were associated with a decrease in firearm suicides (RR 0.89, 95% CI 0.83, 0.96) and overall suicides (RR 0.92, 95% CI 0.86, 0.98) Neither state nor federal minimum purchase age (RRs ranged from 1.00 to 1.08), or minimum possession age (RRs ranged from 0.93 to 1.12) laws were associated with statistically significant changes in any category of youth suicide Permit to purchase laws were unassociated with firearm suicides (RR 0.92, 95% CI 0.76, 1.10) but corresponded to increased non-firearm suicides (RR 1.27, 95% CI 1.00, 1.61)	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Webster (2000)	CAP laws	Time series study with comparison groups. Unit: state-year	Ages: 0–14 years Setting: 50 US states and DC, 1979–1997	National Center for Health Statistics Compressed Mortality Files	Unintentional firearm deaths	CAP laws associated with a 17% (95% CI 3%, 29%; $p = 0.02$) reduction in unintentional firearm deaths. In states where CAP law violation was a felony, there was a 31% decrease (95% CI 15%, 44%; $p = 0.001$). In states where CAP law violation was a misdemeanor, there was a 0% change (95% CI − 19%, 22%, $p = 0.98$) In state-specific analyses, only Florida showed a statistically significant reduction unintentional firearm deaths, with a 51% (95% CI 31%, 75%) reduction. In addition, when Florida (a felony CAP law state) was excluded from the analysis, all statistically significant reductions in the aggregate analysis were lost	Greatest

Table 3 continued

First author (year)	Policies studied	Study design	Population sampled and setting	Outcome measure data source	Primary and secondary outcomes	Main findings	Design Suitability
Xuan (y 2015)	Measure of state firearm legislation strength	Cross-sectional, repeated in 2007, 2009, 2011. Unit: state	Ages: those in grades 9–12 Setting: 31 US states in 2007/2009, and 27 YS states in 2011	Youth Risk Behavior Survey	Self-reported youth gun carriage	Increased firearm policy strength was associated with decreased likelihood of youth gun carrying (AOR 0.91, 95% CI 0.86, 0.96; AOR reflects a 10 point change in the Brady score), and there was evidence that adult gun ownership mediated the relationship between policy strength and youth gun carrying ($p = 0.03$)	Least

CAP child access prevention, *CDC* Centers for Disease Control and Prevention, *ED* emergency department, *WISQARS* Web-based Injury Statistics Query and Reporting System, *WONDER* Wide-ranging Online Data for Epidemiologic Research, *YRBS* Youth Risk Behavior Survey

[a]While we rate the paper by Lott & Whitley (2001) as fitting our criteria for greatest suitability, it should be noted that this paper does not provide information on the source of its outcome data. While our suitability criteria do not specify that information about data sources need to be provided, this is due to our a priori assumption that this information would be present in every scientific paper. It should be noted that some sources (e.g., Santanaella-Tenorio et al., 2016) attribute Lott & Whitley's outcome data to the FBI's Uniform Crime Reports, however this information cannot be verified in the text of the paper

CAP laws with suicide and firearm suicide of 14–17 year olds.

Nonfatal injury across intent type

Four studies, three of least suitable and one of greatest suitable design, analyzed the association of CAP laws with nonfatal firearm injuries. An analysis by Lee et al. (2013), judged to be of least suitable design, focused on the policy's effect on risk for firearm injury relative to non-firearm injuries, not a more proximate outcome, such as the overall rate of firearm injury. They found that youth age 0–20 who lived in states with CAP laws were more likely to be admitted to the hospital for firearm injuries than for other injuries. However, while the age at which these laws impose criminal liability for negligent storage or reckless provision varies, these laws never cover those above age 17. In a sub-analysis, the authors found that children age 0–12 years in CAP law states were less likely to be hospitalized for self-inflicted firearm injuries (compared to non-firearm injuries) than those in states without the law. A study by Simonetti et al. (2015), also of least suitability, found that stricter CAP laws (a binary indicator of being above the median number of law provisions present out of five) were associated with lower self-inflicted and unintentional child and adolescent firearm injuries, but not total or assault-related firearm injuries (meaning firearm injuries resulting from an interpersonal assault).

The other two studies focused, in part, on the differential effects of specific CAP law provisions. Hamilton et al. (2017) stratified the laws by whether they were "strong" (criminal liability for negligent storage of guns) or "weak" (criminal liability can only be imposed for recklessly providing a gun to a child) and found that strong laws were associated with lower total, self-inflicted, and unintentional, but not assault-related, firearm injuries, while weak laws were associated with greater total, self-inflicted, unintentional, and assault-related firearm injuries (Hamilton et al., 2017). The only study on nonfatal firearm injuries to be of greatest suitability (with samples from 11 states over 16 years), DeSimone et al. (2013) found that CAP laws were associated with reductions in total, self-inflicted, and undetermined cause firearm injuries in those $\leq$ 17 years old; results were similar when they tested only CAP laws that provided criminal liability for negligent storage of guns.

Safe storage practices

Finally, CAP laws are hypothesized to reduce firearm injuries and death due to increasing the likelihood of safe storage of guns, but only one study, of least suitability,

tested whether these laws were associated with safe storage. Prickett et al. (2014) conducted a secondary analysis of data from the Early Childhood Longitudinal Study to assess firearm ownership and safety practices among families of preschool-aged youth. They found that the estimated main effect of the laws suggested that parents in CAP law states were less likely to not own guns (relative to owning guns and storing them unsafely) and, among gun owning parents, being in a state with a CAP law was surprisingly associated with an increased the likelihood of keeping their guns unlocked. They also tested an interaction effect and found that when there is a CAP law, the probability of having an unlocked firearm decreases as a function of the overall strength of gun policy in their state (Prickett et al., 2014).

Minimum age restriction laws

Four articles, each of greatest suitability, evaluated minimum age restriction laws on child and adolescent firearm outcomes, but found little evidence of an association. Gius (2015) analyzed unintentional firearm deaths and firearm suicide among 0–19 year olds in all 50 states from 1981 to 2010 and observed that the 1994 *federal* law that set the minimum purchase and possession ages to 18 was associated with reductions in both unintentional firearm death and firearm suicide death, however *state-level* minimum possession age laws were not associated with either outcome. Three other studies, however, did not find an association between either the federal or state minimum age laws and firearm outcomes (Marvell, 2001; Webster et al., 2004; Rosengart et al., 2005).

Purchase-related laws

Two articles, one of highest suitability and one of lowest suitability, focused, at least in part, on the gun purchase-related law of permit-to-purchase or implementation of background check laws more generally. Overall those studies provided limited evidence of the effectiveness of such policies on reducing child and adolescent firearm injuries. Webster et al. (2004) focused on suicide from 1976 to 2001 in each of the fifty states, making it of greatest suitability, and found no evidence of an association between permit-to-purchase laws on total suicides or firearm suicides among youth aged 14–17 years. The second study, one of least suitability, evaluated whether a state's background check system was implemented in a way that was automated and comprehensive (Ruddell and Mays, 2004). They found no association between the background check implementation and unintentional child and adolescent firearm injuries.

Junk gun bans

Only one study, of least suitability, examined the association of junk gun bans with firearm outcomes. Beaver et al. (1993) compared firearm deaths for children under 17 years old before and after the ban was in place, and found the average number of firearm deaths increased from the aggregated cross-section of 1979–1987 compared with the cross-section of 1988–1992.

Stand your ground laws

Lee et al. (2013) study, of least suitability, assessed the effect of stand your ground laws on child and adolescent hospitalizations. The analysis observed that stand-your-ground laws were associated with an increase in the odds that a given injury was firearm-related and, more specifically, this finding applied to firearm assault injuries, accidental firearm injuries, and firearm suicide injuries (Lee et al., 2013). With so few studies, and few rigorous studies, of the impact of the various purchase laws, junk gun bans, and stand your grounds laws on child and adolescent firearm injuries or death, generalizations about their effectiveness cannot be made.

States' firearm legislation strength

Eight studies meeting inclusion criteria explored the relationship between the strength of states' firearm legislation, taking numerous different types of firearm laws into account to derive one more inclusive variable, and child and adolescent firearm outcomes. Each of these studies was of the least suitability. Studies differed with respect to how they operationalized the strength of each state's firearm legislation, which ranged from employing a composite strength of firearm legislation as defined by different grading scales in some studies, to the presence of specific laws (e.g., CAP laws) in others. Age cut-offs with respect to the population studied also differed in these studies, with some studying those up to age 14 years, while others studied youth up to age 20 years. Overall, results were mixed among the studies as to whether firearm legislation strength was associated with child and adolescent firearm outcomes.

Safe storage practices and carriage

Two studies measured the association between firearm legislation strength and either firearm safe storage or self-reported firearm carriage (Prickett et al., 2014) among youth (Xuan & Hemenway, 2015). The study by Prickett et al. (2014) is discussed above; they found no marginal effect of firearm legislative strength of storage habits, but

did find that the effect of firearm legislative strength on storage behaviors differed depending on whether or not the state had a CAP law. Xuan and Hemenway (2015) measured the association between strength of firearm legislation, operationalized using the Brady Center to Prevent Gun Violence's scorecard values, and self-reported youth gun carriage among students in grades 9 through 12. In their fully-adjusted model, a 10-point increase in gun law score (e.g., more restrictive firearm legislation) was associated with a 9% decrease in odds of youth gun carriage.

Fatal and nonfatal injury

Other studies evaluated the relationship between the strength of firearm legislation and firearm injury (fatal and nonfatal) among children (Resnick et al., 2017; Ruddell & Mays, 2004; Safavi et al., 2014; Tashiro et al., 2016). Ruddell and Mays (2004) conducted a cross-sectional study that measured differences in unintentional firearm death rates for those 0–16 years old by strength of firearm regulation, but found no association. Resnick et al. (2017) evaluated the relationship of strength of firearm legislation, using state scorecards from the Brady Campaign and Law Center against Gun Violence as well as the National Rifle Association rankings, with child and adolescent firearm mortality; they found that states with less-restrictive firearm legislation had higher rates of firearm deaths and firearm suicides compared to states with stricter legislation for two aggregated time periods, 2004–2008 and 2009–2013, but not for 1999–2003 (Resnick et al., 2017). A cross-sectional study by Safavi et al. (2014) found that rates of hospitalization for firearm injury were higher in states with less strict firearm legislation. Similarly, Tashiro et al. (2016) assessed the relationship with strength of firearm legislation using the Brady Campaign scorecards and hospital admissions for child and adolescent firearm-related injury by propensity score matching individuals in more lenient states with those in more strict states. The authors found that individuals from states with more lenient legislation had higher rates of in-hospital mortality. Individuals from states with less strict firearm legislation had higher probability of hospitalization for accidental or self-inflicted injury, and lower probability of hospitalization for assault-related injuries.

Finally, there is a single study by Murnan et al. (2004) which measured differences in child and adolescent firearm-related mortality by the presence of five different types of firearm legislation: (1) crime deterrence laws; (2) government control laws; (3) possession laws; (4) safety laws; (5) sales restriction laws. In this one study, none of these types of laws were associated with differences in child and adolescent firearm-related mortality rates.

Discussion

In this scoping review, we identified only 20 studies published from January 1985 through July 2018 that analyzed the association of firearm policies with child and adolescent firearm outcomes. This is an average of 0.6 such papers published per year since 1985. The earliest of these papers was published in 1993 (Beaver et al., 1993), but only one other paper (Cummings et al., 1997) was published before the year 2000. This dearth of research on the effects of firearm policies is not a surprising find; as a field, firearm research is underfunded and generates disproportionately fewer publications compared to research on other leading causes of death (Stark & Shah, 2017). Unfortunately, the implications of this paucity of research are that policymakers and other stakeholders often lack the evidence they need to craft, evaluate, and make informed decisions regarding firearm policies. This should not be interpreted as the policies not having an effect, but rather that the research is often too sparse to measure impact.

Policies

The policy most frequently tested with child and adolescent populations was CAP laws. Two findings from CAP law research reviewed are notable for their consistency across studies of the greatest suitability of design. These findings are that CAP laws are associated with reductions in child and adolescent unintentional firearm deaths (Cummings et al., 1997; Hepburn et al., 2006; Webster & Starnes, 2000) and firearm suicides (Gius, 2015; Webster et al., 2004). Indeed, study results that suggest CAP laws reduce child and adolescent unintentional firearm deaths and firearm suicides have been regarded as some of the strongest results in the field of firearm policy analysis (see, for example, RAND Corporation, 2018). Further investigation in two studies suggests that reductions in unintentional firearm deaths may be driven by states whose CAP laws allow for felony, as opposed to misdemeanor, charges (Hepburn et al., 2006; Webster & Starnes, 2000). This difference between states in allowable charges is just one of many features of CAP laws that vary between states, and it is possible that other variations impact the effectiveness of the law, but few studies investigate what impact these different legislative approaches may have on outcomes.

Beyond CAP laws, general characterizations of the associations of specific firearm policies on child and adolescent firearm outcomes are able to be made for only minimum age firearm restriction laws: None of the included studies found an association between state-level minimum age laws and child and adolescent firearm outcomes (Gius, 2015; Marvell, 2001; Rosengart et al., 2005; Web-

ster et al., 2004), whether unintentional, self-directed, or interpersonal. One study found an association between a federal minimum age restriction and lower suicide and unintentional death rates (Gius, 2015), however. Each of the other specific policies included in this review is analyzed in only one or two studies; too few for general conclusions to be drawn.

There are eight studies that analyze the strength of each state's firearm law landscape on child and adolescent firearm outcomes, with mixed results. For those that find associated reductions, it is unknown whether this is due to a few key policies that tend to be present in states with stronger legal landscapes pertaining to firearms, or perhaps even an interaction among key policies. Which laws may be driving these associated reductions is impossible to disentangle in legislative strength variables and, therefore, specific policy recommendations are unable to be made. To a degree, these summed or weighted legislative strength variables conceptually represent that firearm laws may work synergistically, a concept that is also reinforced by the lone study to explicitly examine between-policy interaction (Prickett et al., 2014). However, to amass evidence on specific policies and allow for policy recommendations to be made, researchers may be better advised to measure potentially important firearm laws separately in their models and test for interactions of laws where warranted.

While this review revealed laws that are understudied, many firearm laws have not been studied for their associations with child and adolescent outcomes *at all*. One potentially promising area of firearm policy is laws related to firearm restrictions for those adults who have proven themselves to be at a high risk for future violence. Assault-related firearm injuries and deaths of those under 18 years old may be perpetrated by those 18 and older (Fowler et al., 2017). Laws designed to reduce the movement of firearms from licit to illicit markets and legal firearm restrictions for high risk individuals may therefore affect firearm injuries and deaths among those under 18 years. For example, laws that allow local authorities to temporarily remove guns from the possession of those deemed high risk for violence against themselves or others through civil extreme risk protection orders (also known as gun violence restraining orders) may safeguard children who would be targets of that violence. Additionally, as noted, domestic violence events are one of the more frequent circumstances of firearm homicide for children, particularly those under 13 years (Fowler et al., 2017). Research suggests that certain laws restricting those under domestic violence restraining orders and, separately, laws restricting violent misdemeanants from gun purchase and possession are associated with reductions in intimate partner homicide (Diez et al., 2017; Vigdor & Mercy, 2006; Zeoli & Webster, 2010; Zeoli et al., 2018). It is, therefore, reasonable to hypothesize that these laws might be associated with child firearm homicide, as well. However these analyses are not currently present in the literature, representing a notable gap.

Outcomes

Twelve studies examined firearm deaths, often disaggregated by intent. Of these, youth firearm homicide victimization was examined in only three studies, with the remaining nine examining firearm suicide, unintentional firearm death, or overall firearm death. This research focus represents a mismatch with the reality of child and adolescent firearm death, the majority of which are homicides (Fowler et al., 2017). The focus on unintentional and suicide deaths is likely a function of the laws most frequently under study. CAP laws and laws determining the minimum age to purchase or possess a gun would not be expected to affect firearm violence committed against children by adults (DeSimone et al., 2013). Indeed, those studies that tested for an association of CAP laws or minimum age laws with firearm homicide found no evidence of one (Cummings et al., 1997; Marvell, 2001; Rosengart et al., 2005).

Nonfatal child and adolescent firearm injuries were measured in only six of the included studies, although they account for the vast majority of firearm injuries overall, with a rate of 7.86 per 100,000 for nonfatal injuries versus 1.76 per 100,000 for fatal injuries (Fowler et al., 2017). Five of the studies analyzing nonfatal injuries were cross-sectional analyses of least suitable design. One likely reason for this lack of rigorous research is the absence of a national surveillance system that systematically tracks nonfatal firearm injuries. Without such a surveillance system, we lack critical information on the scope, geographic distribution, characteristics, and consequences of nonfatal firearm injuries. Such a surveillance system would enable the reliable measurement of nonfatal firearm injuries at the state level over time, allowing for more rigorous time series research to be conducted.

The Agency for Healthcare Research and Quality's Nationwide Inpatient Sample and, separately, Kids Inpatient Database were used to measure nonfatal firearm injuries by studies included in this review (DeSimone et al., 2013; Hamilton et al., 2017; Lee et al., 2013; Safavi et al., 2014; Simonetti et al., 2015; Tashiro et al., 2016), however, these data sources are not necessarily representative of states, include entire states, or include all states (Agency for Healthcare Research and Quality, 2016). Furthermore, by limiting data only to patients who were admitted for inpatient care, these datasets exclude the majority of children who are discharged from hospital emergency departments after a non-fatal firearm injury (Carter et al., 2017). Regardless, these inpatient databases currently represent

one of the few standardized, large-scale sources of nonfatal firearm injury data in the United States, yet estimates generated using them may be biased due to these sampling issues. While firearm uses resulting in injuries are often criminal matters, there are currently no nationwide criminal justice surveillance systems that specifically collect these data. For example, the National Incident-Based Reporting System, which is currently participated in by less than 40% of law enforcement agencies in the US (Federal Bureau of Investigation, 2017), collects incident-level data from law enforcement jurisdictions but does not collect data on unintentional or self-inflicted firearm injuries. It is also difficult, at best, in this system to disaggregate aggravated assaults in which firearms were used from interpersonal violence in which firearms caused injury.

As has been discussed in previous reviews, a main limitation of firearm policy analyses is that they lack data on whether and how the laws are implemented (see, for example, Zeoli et al., 2016). For example, CAP laws are hypothesized to promote safe storage of guns, thereby reducing children's access to guns and resulting in fewer firearm injuries and deaths than would result if children had access to guns. With the exception of the research by Prickett et al. (2014), which examined locked firearm storage as an outcome variable in an investigation of CAP laws, none of the included studies had data on the intermediate steps in this logic model. Implementation and enforcement data on firearm laws, particularly systematically collected data for numerous states over several years, is difficult and often impossible to obtain. Systematic implementation data for CAP laws, which require people to engage in an act within the privacy of their homes, is certainly unavailable. It is therefore unknown to what extent adults respond to CAP laws by changing gun storage behaviors to prevent child access. If the laws are not being implemented properly, we cannot expect to see a policy impact. Similarly, if we do see an association, but the laws are not being implemented, then that association is likely the product of confounding.

The concept of confounding leads to a second main limitation of ecological-level policy analyses research, namely that it is often not possible to disentangle contemporaneous secular changes and associated impacts from the estimated effects of the policies. It may be, for example, that there was broad public support, with accompanying behavior changes to safer firearm storage, for CAP laws before these laws were passed. The cross-sectional study by Prickett et al. (2014), while suggestive that the likelihood of having locked versus unlocked guns is greater in states with these laws, does not establish whether safe storage was more frequent in states after the laws were enacted than before. It is possible that the behavior changes preceded the law enactment and confounded the estimated effect of the law.

This scoping review is limited in multiple ways. As a scoping review, our keyword search for relevant literature is not as extensive as it would have been for a systematic review. Similarly, we did not search as many literature databases as would be necessary for a systematic review. We therefore may have missed some papers that met inclusion criteria. Given our a priori knowledge of the extent of the literature and our more general objective of describing the state of knowledge and developing research recommendations, a scoping review was deemed appropriate. Additionally, we focused here solely on those results that were specific to child and adolescent populations. Associations of any of the laws covered in this review with the larger population may differ from their associations with child and adolescent outcomes.

Despite these limitations and broad need for more research and better data, there is reason to be optimistic. First, because rigorous research suggests that CAP laws may be effective in reducing child and adolescent unintentional firearm death and firearm suicide, and because there is evidence that firearm policies may work together to reduce the burden of child and adolescent firearm outcomes. Second, because this review reveals a firm research agenda that, if accomplished, will inform policy makers and advocates as they make decisions on firearm policy into the future. First, existing research shows that, even with crude policy sub-divisions, between-state heterogeneity in policy provisions result in differential policy effects (e.g., Cummings et al., 1997). Research is needed to better characterize between-state differences in provisions so researchers can determine what components affect outcomes most. Second, with few exceptions (e.g., Prickett et al., 2014), synergistic policy effects are largely unanalyzed. Studies applying overall policy scores and those including multiple policies in one model have provided valuable information, but optimal policy solutions require understanding how particular policies modify each other's effects. The third primary need is for more reliable sources of non-fatal firearm data, given that the majority of the overall burden falls into this category. This need has been acknowledged elsewhere (Webster, 2018), and addressing this problem will allow for the addressing of research questions that were heretofore not rigorously answerable.

Acknowledgements We would like to thank Lynn Massey for her assistance in motivating us and helping us work out all the logistical and technical aspects of conducting the review. We would like to thank Judith E. Smith, Informationist at the Taubman Health Sciences Library, University of Michigan, for creating and conducting the search strategies.

Funding This review was funded by NIH/NICHD 1R24HD087149-01A1. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the funding agencies.

Compliance with ethical standards

Conflict of interest April M. Zeoli, Jason Goldstick, Amanda Mauri, Mikaela Wallin, Monika Goyal and Rebecca Cunningham have no financial relationships relevant to this article to disclose.

Human and animal rights and Informed consent This article does not contain any studies with human participants or animals performed by any of the authors.

References

Agency for Healthcare Research and Quality. (2016). *Why the NIS should not be used to make state-level estimates*. Healthcare Cost and Utilization Project (HCUP). Retrieved November 11, 2018 from www.hcup-us.ahrq.gov/db/nation/nis/nis_statelevelestimates.jsp

Beaver, B. L., Woo, S., Voigt, R. W., Moore, V. L., Smialek, J., Suter, C., et al. (1993). Does handgun legislation change firearm fatalities? *Journal of Pediatric Surgery, 28,* 306–309.

Briss, P. A., Zaza, S., Pappaioanou, M., Fielding, J., Wright-De Agüero, L., Truman, B. I., et al. (2000). Developing an evidence-based Guide to Community Preventive Services—Methods. *American Journal of Preventive Medicine, 18*(1S), 35–43.

Carter, P. M., Cook, L. J., May, M. L., Zonfrillo, M. R., Stanley, R. M., Chamberlain, J. M., et al. (2017). Individual and neighborhood characteristics of children seeking emergency department care for firearm injuries within the PECARN Network. *Academic Emergency Medicine, 24,* 803–813.

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. (2018). *Web-based Injury Statistics Query and Reporting System (WISQARS)* [online]. www.cdc.gov/injury/wisqars

Corporation, R. A. N. D. (2018). *The science of gun policy: A critical synthesis of research evidence on the effects of gun policies in the United States*. Santa Monica, CA: RAND Corporation.

Cummings, P., Grossman, D. C., Rivara, F. P., & Koepsell, T. D. (1997). State gun safe storage laws and child mortality due to firearms. *JAMA, 278,* 1084–1086.

Cunningham, R. M., Walton, M. A., & Carter, P. M. (2018). The major causes of death in children and adolescents in the United States. *New England Journal of Medicine, 379,* 2468–2475.

DeSimone, J., Markowitz, S., & Xu, J. (2013). Child access prevention laws and nonfatal gun injuries. *Southern Economic Journal, 80,* 5–25.

Diez, C., Kurland, R., Rothman, E. F., Bair-Merritt, M., Fleegler, E., Xuan, Z., et al. (2017). State intimate partner violence-related firearm laws and intimate partner homicide rates in the United States, 1991 to 2015. *Annals of Internal Medicine, 167,* 536–543.

Federal Bureau of Investigation, Department of Justice. (2017). *FBI releases 2016 NIBRS Crime statistics in report and CDE, promotes transition of agencies*. Retrieved from https://ucr.fbi.gov/nibrs/2016/resource-pages/nibrs-2016_summary.pdf

Fowler, K. A., Dahlberg, L. L., Haileyesus, T., Gutierrez, C., & Bacon, S. (2017). Children firearm injuries in the United States. *Pediatrics, 140,* e20162486.

Gius, M. (2015). The impact of minimum age and child access prevention laws on firearm-related youth suicides and unintentional deaths. *The Social Science Journal, 52,* 168–175.

Hamilton, E. C., Miller, C. C., Cox, C. S., Lally, K. P., & Austin, M. T. (2017). Variability of child access prevention laws and pediatric firearm injuries. *Journal of Trauma and Acute Care Surgery, 84,* 613–619.

Hepburn, L., Azrael, D., Miller, M., & Hemenway, D. (2006). The effect of child access prevention laws on unintentional child firearm fatalities, 1979-2000. *The Journal of Trauma Injury, Infection, and Critical Care, 61,* 423–428.

Lee, J., Moriarty, K. P., Tashjian, D. B., & Patterson, L. A. (2013). Guns and states: Pediatric firearm injury. *Journal of Trauma and Acute Care Surgery, 75,* 50–53.

Lott, J. R., & Whitley, J. E. (2001). Safe storage gun laws: Accidental deaths, suicides, and crime. *Journal of Law and Economics, 44,* 659–689.

Marvell, R. B. (2001). The impact of banning juvenile gun possession. *Journal of Law and Economics, 44,* 691–713.

Murnan, J., Dake, J. A., & Price, J. H. (2004). Association of selected risk factors with variation in child and adolescent firearm mortality by state. *The Journal of School Health, 74,* 335–340.

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—A web and mobile app for systematic review. *Systematic Reviews, 5,* 210–219.

Prickett, K. C., Martin-Story, A., & Crosnoe, R. (2014). State firearm laws, firearm ownership, and safety practices among families of preschool-aged children. *American Journal of Public Health, 104,* 1080–1086.

Resnick, S., Smith, R. N., Beard, J. H., Holena, D., Reilly, P. M., Schwab, C. W., et al. (2017). Firearm deaths in America: Can we learn from 462,000 lives lost? *Annals of Surgery, 266,* 432–440.

Rosengart, M., Cummings, P., Nathens, A., Heagerty, P., Maier, R., & Rivara, F. (2005). An evaluation of state firearm regulations and homicide and suicide death rates. *Injury Prevention, 11,* 77–83.

Ruddell, R., & Mays, G. L. (2004). Risky behavior, juveniles, guns, and unintentional firearms fatalities. *Youth Violence and Juvenile Justice, 2,* 342–358.

Safavi, A., Rhee, P., Pandit, V., Kulvatunyou, N., Tang, A., Aziz, H., et al. (2014). Children are safer in states with strict firearm laws: A National Inpatient Sample study. *Journal of Trauma Acute Care Surgery, 76,* 146–150.

Santaella-Tenorio, J., Cerdá, M., Villaveces, A., & Galea, S. (2016). What do we know about the association between firearm legislation and firearm-related injuries? *Epidemiologic Reviews, 38,* 140–157.

Simonetti, J. A., Rowhani-Rahbar, A., Mills, B., Young, B., & Rivara, F. (2015). State firearm legislation and nonfatal firearm injuries. *American Journal of Public Health, 105,* 1703–1709.

Stark, D. E., & Shah, N. H. (2017). Funding and publication of research on gun violence and other leading causes of death. *JAMA, 317,* 84–85.

Tashiro, J., Lane, R. S., Blass, L. W., Perez, E. A., & Sola, J. E. (2016). The effect of gun control laws on hospital admissions for children in the United States. *Journal of Trauma and Acute Care Surgery, 81,* S54–S60.

Vigdor, E. R., & Mercy, J. A. (2006). Do laws restricting access to firearms by domestic violence offenders prevent intimate partner homicide? *Evaluation Review, 30,* 313–346.

Webster, D. W. (2018). *A critical gap in gun violence data*. Retrieved November 12, 2018 from https://americanhealth.jhu.edu/article/critical-gap-gun-violence-data

Webster, D. W., & Starnes, M. (2000). Reexamining the association between child access prevention gun laws and unintentional shooting deaths of children. *Pediatrics, 106,* 1466–1469.

Webster, D. W., Vernick, J. S., Zeoli, A. M., & Manganello, J. A. (2004). Association between youth-focused firearm laws and youth suicides. *JAMA, 292,* 594–601.

Xuan, Z., & Hemenway, D. (2015). State gun law environment and youth gun carrying in the United States. *JAMA Pediatrics, 169,* 1024–1031.

Zeoli, A. M., Malinski, R., & Turchan, B. (2016). Risks and targeted interventions: Firearms in intimate partner violence. *Epidemiologic Reviews, 38,* 125–139.

Zeoli, A. M., McCourt, A., Buggs, S., Frattaroli, S., Lilley, D., & Webster, D. W. (2018). Analysis of the strength of legal firearms restrictions for perpetrators of domestic violence and their associations with intimate partner homicide. *American Journal of Epidemiology, 187,* 2365–2371.

Zeoli, A. M., & Webster, D. W. (2010). Effects of domestic violence policies, alcohol taxes and police staffing levels on intimate partner homicide in large US cities. *Injury Prevention, 16,* 90–95.