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Officer-Involved Shootings and Concealed Carry Weapons Permitting Laws: Analysis of Gun Violence Archive Data, 2014–2020

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Abstract About 1,000 civilians are killed every year by a law enforcement officer in the USA, more than 90% by firearms. Most civilians who are shot are armed with a firearms. Higher rates of officer-involved shootings (OIS) are positively associated with state-level firearm ownership. Laws relaxing restrictions on civilians carrying concealed firearms (CCW) have been associated with increased violent crime. This study examines associations between CCW laws and OIS. We accessed counts of fatal and nonfatal OIS from the Gun Violence Archive (GVA) from 2014–2020 and calculated rates using population estimates. We conducted legal research to identify passage years of CCW laws. We used an augmented synthetic control models with fixed effects to estimate the effect of Permitless CCW law adoption on OIS over fourteen biannual semesters. We calculated an inverse variance weighted average of the overall effect. On average, Permitless CCW adopting states saw a 12.9% increase in the OIS victimization rate or an additional 4 OIS victimizations per year, compared to what would have happened had law adoption not occurred. Lax laws regulating civilian carrying of concealed firearms were associated with higher incidence of OIS. The increase in concealed gun carrying frequency associated with these laws may influence the perceived threat of danger faced by law enforcement. This could contribute to higher rates of OIS.

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Introduction

In the mid-2010's, several media and nonprofit organizations began collecting data on officer involved shooting (OIS) incidents using open-source data collection methods to better understand incident frequency. These sources, including The Counted, developed by *The Guardian* [1]; Fatal Force, developed by the *Washington Post* [2]; the Gun Violence Archive [3]; and others [4, 5] identify incidents more comprehensively than the Centers for Disease Control and Prevention (CDC), which often undercount or misclassify police involvement in homicides and provide no estimates of nonfatal shootings [6, 7]. These sources estimate around 1,000 fatal OIS per year [8] and have been recently validated against newer, national-level repositories (e.g., the National Violent Death Reporting System) with better, though incomplete, data [9].

Several studies have examined the relationship between firearm prevalence and state-level laws and fatal OIS in the USA [8, 10]. Hemenway and colleagues (2018) used data from the *Washington Post's* Fatal Force database to examine fatal OIS across the USA; finding rates of fatal OIS per 1 million (M) population were significantly associated with firearm availability at the state level [8]. The authors hypothesized that the relationship between fatal OIS and gun ownership may be due to increases in both the likelihood of an officer encountering an armed person and officers' perceived risk of personal injury in an encounter where gun ownership is prevalent [8]. Nagin (2020) also found that fatal OIS rates were associated with firearm availability at the state level [10]. Kivisto and colleagues (2017) examined whether state-level firearm legislation impacted rates of fatal OIS. They identified that states with stronger legislative strength scores had lower rates of fatal police shootings per 1 M population [11].

A prior analysis of fatal OIS has found that most incidents occurred outside the home, and the majority of victims were armed with a firearm [12]. Over the past four decades, most states have implemented Shall Issue concealed carry weapons (CCW) laws or Permitless CCW laws which make public carry of a concealed weapon easier [13–16]. These laws, often referred to as right-to-carry (RTC) laws, can remove law enforcement discretion in issuing CCW permits (Shall Issue) or drop the need for a permit all together (Permitless) compared to states without RTC laws, which allow law enforcement broad discretion to deny permits (May Issue). A recent survey of gun owners found states with RTC laws have higher rates of self-reported public concealed gun carrying than that of states without [16]. As of 2021, there are 21 states with Permitless carry, 21 states with some form of Shall Issue laws, and 8 states with May Issue laws.

The fluctuations in these state laws have provided researchers the opportunity to examine their impact on firearm violence. Early research on CCW laws from Lott and Mustard (LM) found an association between adopting a Shall Issue CCW law from a May or a No Issue CCW law and reductions in crime [17]. However, this research contained flaws including measurement error in law adoption time, the use of an endogenous explanatory variable, inclusion of over 35 colinear covariates, and omission of variables shown to affect crime (police presence and incarceration rates) [18, 19]. More recent research examining the impact of these laws have addressed these methodological issues [20]. While the findings have been somewhat mixed, a majority of recent studies have found evidence that RTC laws increase violent crime including homicides [13, 14, 19, 21–26]. As firearm availability is associated with increased fatal OIS, Shall Issue and Permitless CCW laws could influence fatal and nonfatal rates of OIS; however, the impact of RTC laws on OIS is currently unknown.

Given the relationship between state-level firearm availability and OIS, and the impact of RTC laws on public gun carrying, we sought to understand the impact of changes in CCW permitting laws on OIS. We hypothesized that removing the need for a permit to carry a concealed weapon in public would be associated with increased incidence of OIS rates.

Methods

We conducted a comparative time-series analysis to evaluate the impact of Permitless CCW laws on rates of total (fatal + non-fatal) OIS violence using the Gun Violence Archive (GVA). The GVA is the only source that provides an accounting of both fatal and nonfatal firearm injuries to civilians as part of an OIS incident.

Data and Measures

We accessed counts of total OIS violence from the GVA from 2014 to 2020. Counts of total, fatal, and nonfatal OIS violence are provided in Supplemental Table 1. The GVA, a nonprofit organization, uses law enforcement, media, government, and commercial sources to provide a daily account of firearm violence throughout the USA. We selected the GVA because it is the only source that attempts to capture both fatal and nonfatal data. The data is fully accessible and available for free to download. We used 2014 as our starting year as this was the first full year data were available [27]. Earlier studies have used the GVA to examine firearm violence [28]. Other studies have used the GVA to validate other national databases as sources of data for police involved shootings [9]. GVA provides links to the news media reports it uses to provide gun violence frequency. GVA categorizes violence by several types of incidents (e.g., officer involved shooting, child involved incident, drive by etc.). Incident output has the following variables: incident state, day, address, number of persons killed, and number of persons injured. We downloaded all OIS incidents from 2014 to 2020. We manually reviewed all OIS incidents from 2014 to 2020 to exclude law enforcement officers shot as part of an OIS incident or when an officer fired their weapon, but no one was wounded or killed. The GVA does not provide race/ethnicity of victims. GVA was selected over other data sources as it is the only national source of fatal and nonfatal OIS.

Our analysis focused on the impact of adopting a Permitless CCW law from a Shall Issue CCW law or the impact of removing the permit requirement to carry a concealed weapon. We conducted legal research to identify implementation dates and Shall Issue CCW permit provisions for all 50 States. We collected these provisions from the Westlaw and HeinOnline legal research databases. To identify the relevant policies, we used a standard search strategy for each state for the years 1980–2020. We classified states by whether they issued CCW permits on a May Issue basis, Shall Issue basis, or allowed for Permitless carry. All laws were operationalized dichotomously, with "0" representing the absence of a law and "1" representing the presence of a law. No states moved from a May Issue CCW law to a Permitless CCW law. Table 1 provides the status of each state's CCW law regime and the year of law adoption.

Analysis

To examine the relationship between CCW laws and OIS, we collapsed data to the semester-level or two time periods per year, giving us 14 time periods from 2014 to 2020 over 50 states or 700 state-time indexes. Our outcome of interest was the total number of victims fatally and nonfatally shot by police indexed by state-year. We employed a comparative time-series analysis approach to explore the relationship between CCW permitting laws and rates of total OIS violence.

The following covariates were included in the study's analyses: percent population living in MSA, black males 15–19, white males 15–19, unemployed, per capital alcohol consumption, rate of incarceration, and law enforcement officers per capita. The rates of incarceration and police employment were interpolated for 2019 and 2020. All other variables were linearly extrapolated for 2020. Covariates were acquired from the US Census Bureau [29], the Bureau of Labor Statistics [30], the Bureau of Justice Statistics [31], the Uniform Crime Reports [32], and the National Institute on Alcohol Abuse and Alcoholism [33].

To look at the average treatment effect on the treated (ATT) of adopting a Permitless CCW system on OIS, we considered four potential model specifications related to the synthetic control method including synthetic control models (SCM) [34–36], SCM with fixed effects (SCM + Fixed effects) [37–39], augmented synthetic control models (ASCM) [37], and ASCM with fixed effects (ASCM + Fixed effects) [37–39]. The ASCM builds off the SCM developed by Abadie and Gardeazabal (2003) [34–36]. The SCM, which creates a weighted synthetic state based on covariate values, referred to as the control state, reduces bias when estimating the effects of a new state policy. The method uses a pool of "non-treated" states or states without the policy of interest, to identify a weighted combination of states that mirrors the treated state prior to the law change or pre-law adoption period. This creates a control state with limited selection bias likely to satisfy the parallel line assumption necessary for causal inference and act as a counterfactual to compare what would have happened in the treated state had the law not been changed. Specifying a fixed effect, referred to as demeaning, subtracts the pre-treatment mean within the treatment and donor states from each outcome observation prior to identifying the weighted synthetic state [38, 39].

The ASCM method, developed by Ben-Michael, Feller, and Rothstein (2019), builds on the original SCM [37]. In the original SCM, the ability of the synthetic control state to act as the treatment state's counterfactual is measured by the pre-treatment root mean square error (RMSE) or the how different the treated state and control state are prior to the law change. For certain interventions, where the potential donor pool is small, or the pre-treatment RMSE fit is infeasible, the SCM may not act as an accurate counterfactual as the pre-adoption trend lines may diverge. The ASCM uses ridge regression as an outcome model and extends the SCM to policy settings where pre-treatment RMSE fit is poor. The ridge regression outcome model estimates the bias arising from inadequate pre-treatment RMSE fit and de-biases the synthetic control estimate [37]. In a traditional SCM, donor state weights are always nonnegative. ASCM with ridge regression produces donor state weights that can be negative as it seeks to minimize variance, which allows for improved pre-treatment RMSE fit. As part

Table 1 Legal landscape of concealed carry weapon laws

State	Overall concealed carry permitting law			
	No Issue	May Issue permits	Shall Issue permits	Permitless Carry
Alabama		Pre-1980–8/1/13	8/1/13[a]	
Alaska	Pre-1980–10/1/94		10/1/94–9/9/03	9/9/03
Arizona	Pre-1980–7/16/94		7/16/94–7/28/10	7/28/10
Arkansas	Pre-1980–7/27/94		7/27/94[a]	
California		Pre-1980		
Colorado	Pre-1980–6/8/81	6/8/81–5/17/03	5/17/03[a]	
Connecticut		Pre-1980		
Delaware		Pre-1980		
Florida		Pre-1980–10/1/87	10/1/87	
Georgia		Pre-1980–8/25/89	8/25/89[a]	
Hawaii		Pre-1980		
Idaho		Pre-1980–7/1/90	7/1/90–7/1/16	7/1/16
Illinois	Pre-1980–1/5/14		1/5/14[a]	
Indiana			Pre-1980[a]	
Iowa		Pre-1980–1/1/11	1/1/11[a]	
Kansas	Pre-1980–1/1/07		1/1/07–7/1/15	7/1/15
Kentucky	Pre-1980–10/1/96		10/1/96–6/27/19	6/27/19
Louisiana	Pre-1980–4/19/96		4/19/96	
Maine	Pre-1980–9/18/81		9/18/81–10/15/15	10/15/15
Maryland		Pre-1980		
Massachusetts		Pre-1980		
Michigan		Pre-1980–7/1/01	7/1/01	
Minnesota		Pre-1980–5/28/03	5/28/03[a]	
Mississippi	Pre-1980–7/1/91		7/1/91–4/15/16	4/15/16
Missouri	Pre-1980–2/26/04		2/26/04–1/1/17[a]	1/1/17
Montana		Pre-1980–10/1/91	10/1/91[a]	
Nebraska	Pre-1980–1/1/07		1/1/07	
Nevada		Pre-1980–10/1/95	10/1/95	
New Hampshire			Pre-1980–2/22/17[a]	2/22/17
New Jersey		Pre-1980		
New Mexico	Pre-1980–1/1/04		1/1/04	
New York		Pre-1980		
North Carolina	Pre-1980–12/1/95		12/1/95	
North Dakota	Pre-1980–8/1/85		8/1/85–8/1/17	8/1/17
Ohio	Pre-1980–4/8/04		4/8/04	
Oklahoma	Pre-1980–9/1/95		9/1/95–11/1/19	11/1/19
Oregon		Pre-1980–1/1/90	1/1/90[a]	
Pennsylvania		Pre-1980–6/17/89	6/17/89[a]	
Rhode Island			Pre-1980[a]	
South Carolina		Pre-1980–8/23/96	8/23/96	
South Dakota		Pre-1980–7/1/85	7/1/1985–7/1/19	7/1/19
Tennessee	Pre-1980–11/1/89	11/1/89–10/1/96	10/1/96	
Texas	Pre-1980–1/1/96		1/1/96	
Utah		Pre-1980–5/1/95	5/1/95[a]	
Vermont				Pre-1980

Table 1 (continued)

State	Overall concealed carry permitting law			
	No Issue	May Issue permits	Shall Issue permits	Permitless Carry
Virginia		Pre-1980–7/1/95	7/1/95[a]	
Washington			Pre-1980	
West Virginia		Pre-1980–7/7/89	7/7/89–5/24/16	5/24/16
Wisconsin	Pre-1980–11/1/11		11/1/11	
Wyoming	Pre-1980–7/1/83	7/1/83–10/1/94	10/1/94–7/1/11[a]	7/1/11

[a]denotes some limited discretion afforded the issuing agency

of the pre-treatment trend creation, the augmentation uses a leave-one-out cross-validation process to identify the value of λ. This provides the optimal λ value, 2 standard deviations above the minimum λ value, to protect against overfitting.

We used a data-driven approach in our model selection process. We evaluated the following diagnostics and present each below and in the supplemental material. First, we plotted the overall pre-treatment RMSE and the divergent pre-treatment RMSE or the RMSE in the last two semesters of pre-treatment period. Model specifications with similar overall and divergent pre-treatment RMSE indicate a well performing and consistent counterfactual. Models with disparate RMSE values would suggest fluctuations close to treatment adoption and thus a potentially biased ATT. Second, we inspected gap plots related to the four potential model selections to examine pre-treatment RMSE trends. This evaluation provided a visual representation of the overall and divergent pre-treatment RMSE and thus how well the synthetic counterfactual could best mirror the treatment state had the policy not been adopted. All analyses were conducted using R [31ss] with the package "augsynth" [41]. We provide pre-treatment donor weights for treated state across model specifications as well as pre-treatment mean covariate values for treated and synthetic states across each model specification.

We examined the impact of adopting a Permitless CCW system from a Shall Issue CCW system using a three-semester moving average of OIS rates per 1 million (M) population for 11 treatment states (Table 1). We compared each Permitless CCW adopting state to a donor pool of Shall Issue states that did not change their permitting system between 2014 and 2020 ($n = 26$). The ATT for each Permitless CCW adopter was calculated as the average difference in mean OIS rate between the treated state and the augmented synthetic control state in the post-implementation period. We specified jackknife standard errors [42]. For each state, we divided the average population size by 1 M and multiplied by the ATT to understand how many OIS were associated with law adoption.

To understand the overall ATT across law adopters, we calculated an inverse variance weighted average ATT in R using the package "meta," [43] specifying random effects assuming a heterogenous treatment effect. These analyses excluded states with poor performing RMSE, defined as pre-treatment RMSE greater than 2 standard deviations above the mean. As a sensitivity analysis, we separately examined the rate of fatal and nonfatal OIS violence presenting the inverse variance weighted average ATT.

Results

Figure 1 provides the median counts for total, fatal, and nonfatal OIS violence from 2014–2020. The median count for total OIS violence slightly fluctuated during the 7-year study period starting slightly below 20 in the first semester of 2014 and ending slightly above 20 in the second semester of 2020. Notably, the disaggregated median counts of fatal and nonfatal OIS violence were similar across time. Figures 2, 3, and 4 are diagnostic plots specific to Missouri. Diagnostic plots and tables for all other states are in the Supplemental Material. Figure 2 and Supplemental Figs. 1–10 provide the donor state weights that make up each of the synthetic controls. Supplemental Figs. 11–17 provide the mean value of

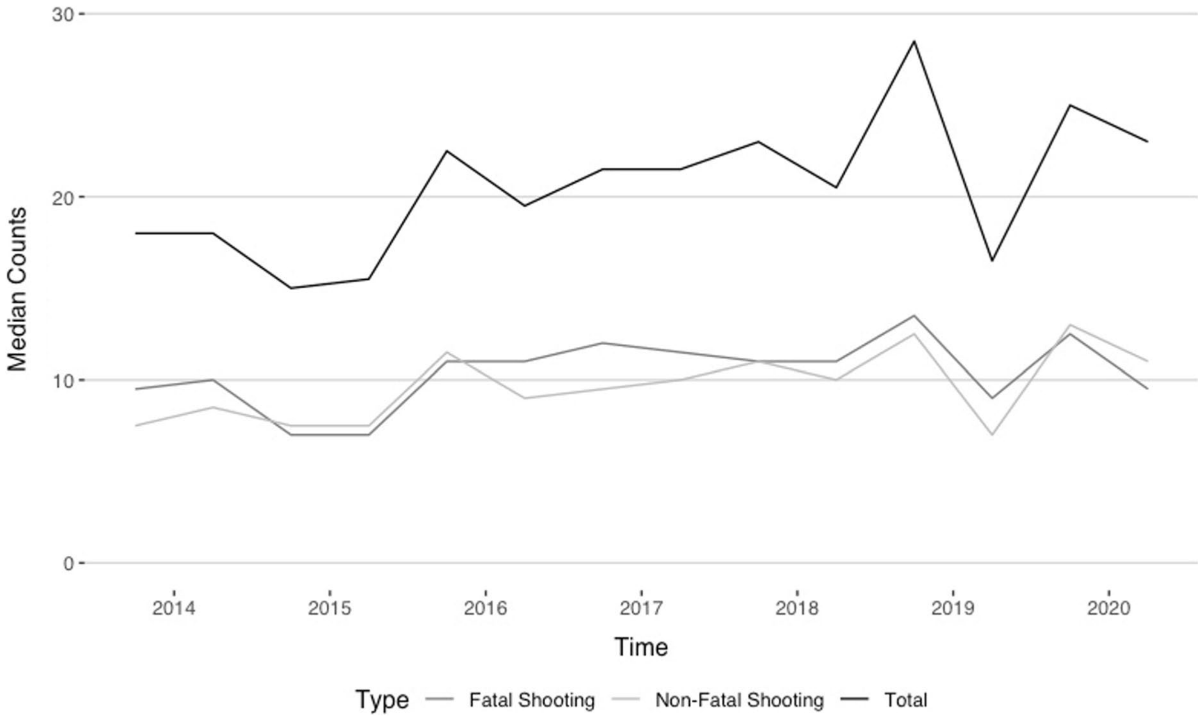
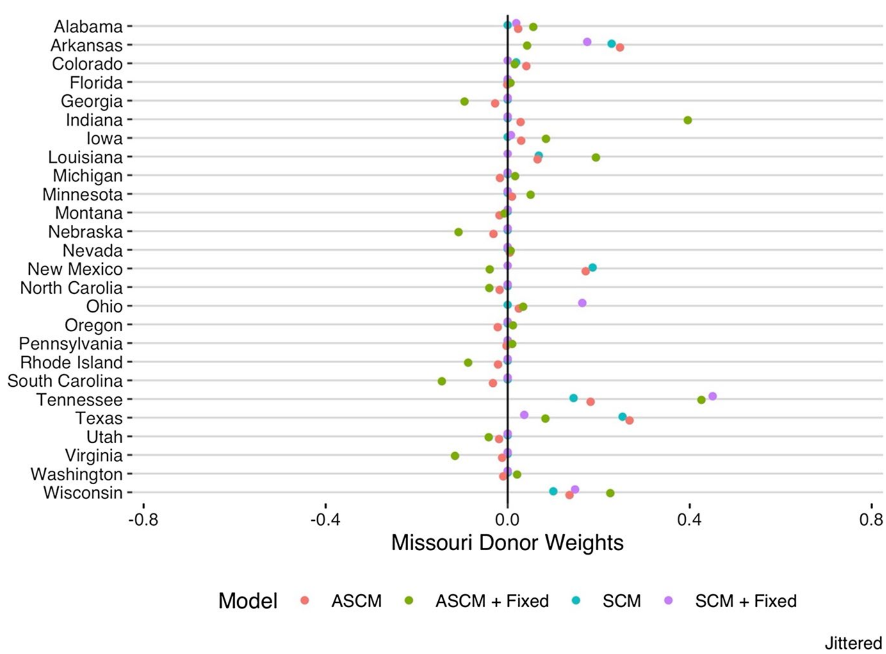


Fig. 1 Median counts of total, fatal, and nonfatal shootings in the USA, 2014–2020 Gun Violence Archive Data

Fig. 2 Comparison of donor weights across model specifications for Missouri, 2014–2020 Gun Violence Archive data



covariates for the treated and synthetic control states during the pre-treatment period across our four model specifications.

Figure 3 provides the overall and divergent RMSE in the pre-treatment period. Examining the overall RMSE, it appears the ASCM + Fixed effect model

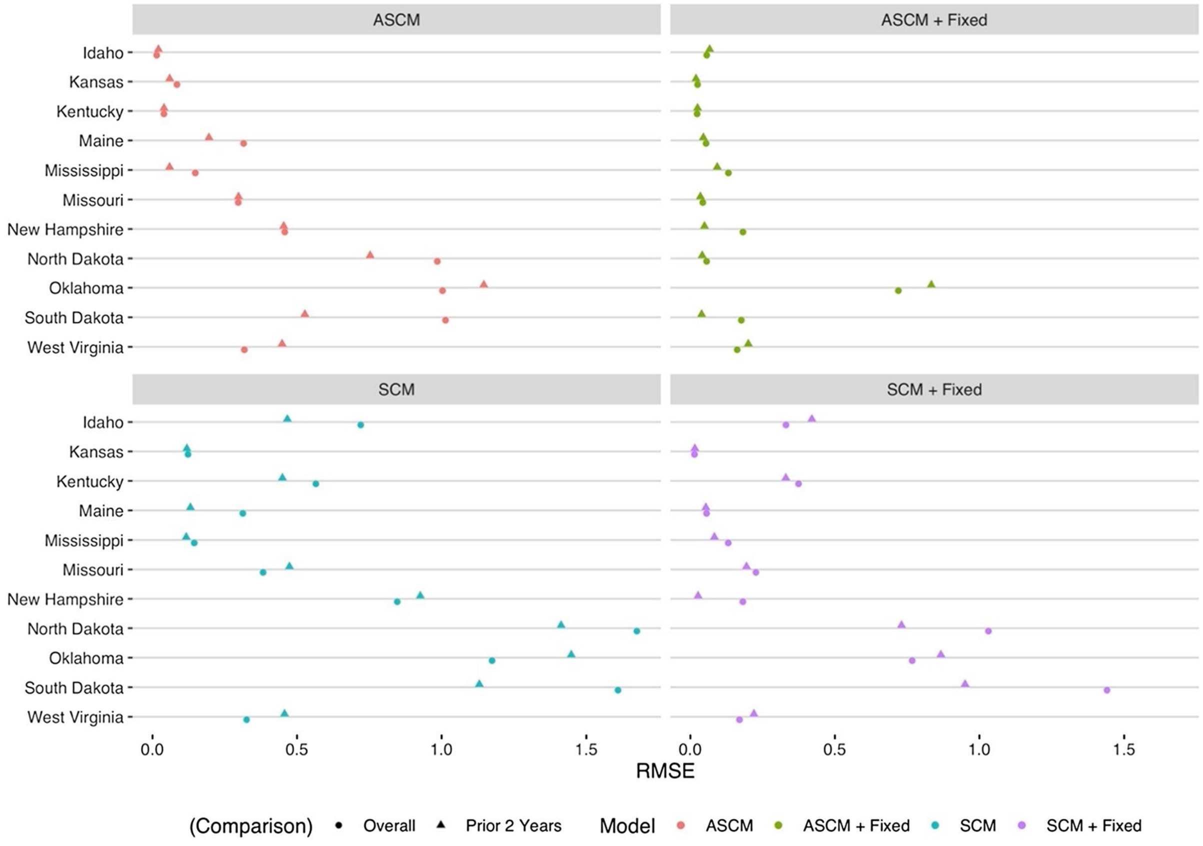


Fig. 3 Comparison of RMSE and pre-treatment RMSE divergence across model specifications

has the smallest RMSE in the pre-treatment period. The ASCM + Fixed effects, excluding Oklahoma, are all generally close to 0, indicating strong pre-treatment fit. The ASCM model provides strong pre-treatment fit for majority of states, excluding North Dakota, Oklahoma, and South Dakota. The SCM and SCM + Fixed effect models indicate comparatively large RMSE considering the ASCM models. Examining the relationship between overall RMSE and divergent RMSE indicates that both the ASCM and ASCM + Fixed effects produced consistent RMSE, with limited divergence in the time periods immediately preceding the treatment year. The SCM and SCM + Fixed effects displayed large RMSE divergence within states. Overall and divergent RMSE performance can be visually seen in the gap plots presented in Fig. 4 and Supplemental Figs. 18–27, which display the difference between treatment and synthetic control across model specifications. Figure 4 reveals that Missouri's pre-treatment RMSE performance is the strongest for the ASCM + Fixed effect model.

Overall, adopting a Permitless CCW law from a Shall Issue law resulted in an additional 0.78 OIS victims per 1 M population per semester or an additional 2 OIS victims per semester than what we would have normally expected across all states that adopted Permitless carry (Fig. 5). This represents a 12.9% increase in OIS victimization rate. We excluded Oklahoma from this analysis as its overall RMSE was greater than 2 standard deviations above the average, indicating a poor counterfactual from which to draw inference. Idaho (ATT = 2.01; SE = 0.931), Mississippi (ATT = 0.88; SE = 0.304), Missouri (ATT = 2.08; SE = 0.529), and West Virginia (ATT = 1.59; SE = 0.514) had significantly greater average rates of OIS in the post-law adoption period compared to the pre-law adoption period compared to their synthetic control states. In the post-law period, the results suggest that Idaho averaged an additional

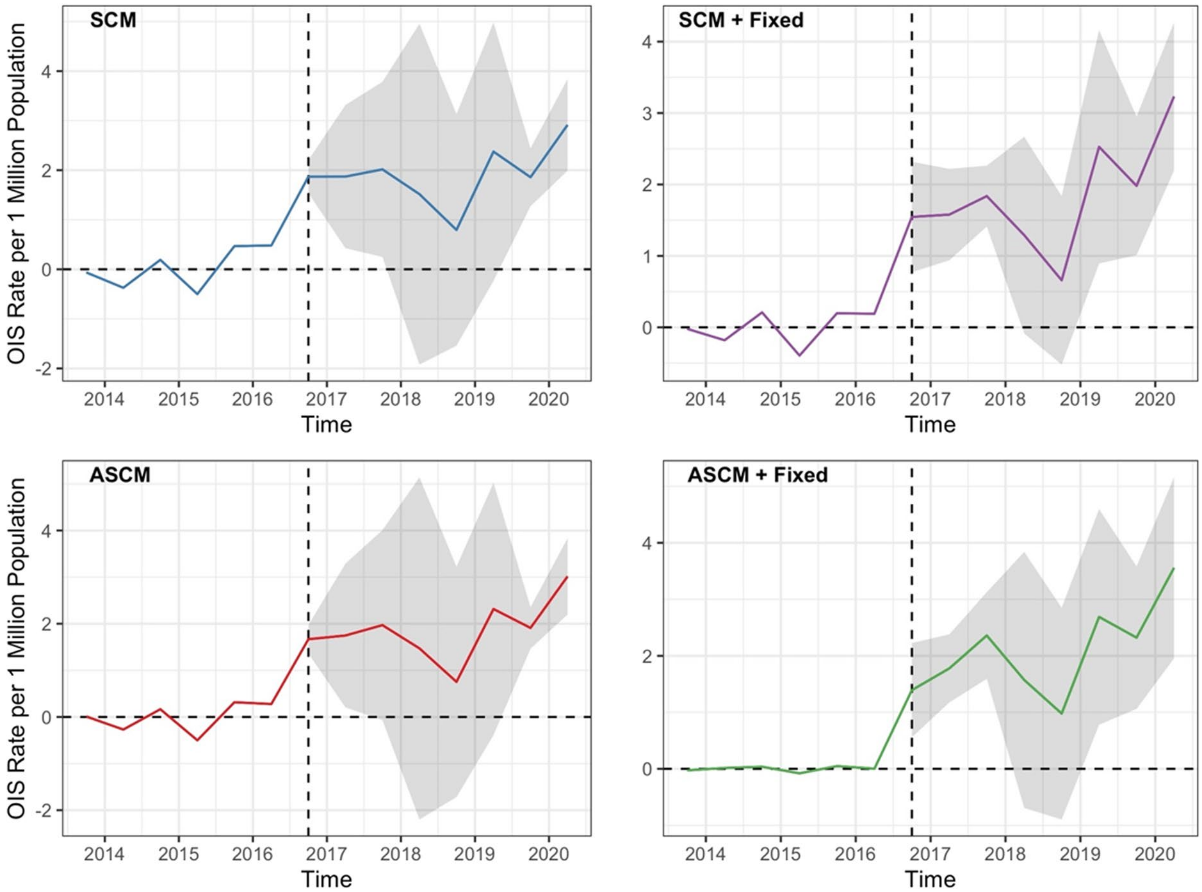
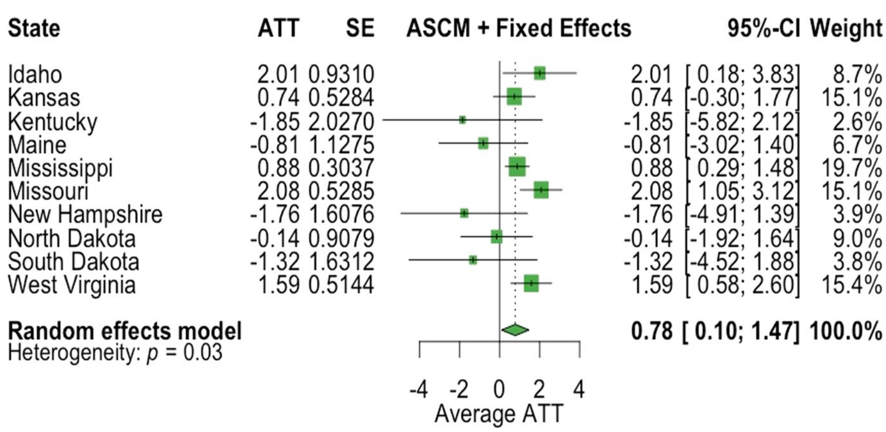


Fig. 4 Gap plot comparison of model specifications related to the impact of permitless concealed carry weapons law adoption on officer involved shooting rates per 1 million in Missouri, 2014–2020 Gun Violence Archive data

Fig. 5 Impact of permitless concealed carry weapons law adoption on officer involved shooting rates per 1 million, 2014–2020 Gun Violence Archive data



3.53 OIS victims per semester, Mississippi averaged an additional 2.63 OIS victims per semester, Missouri averaged an additional 12.76 OIS victims per semester, and West Virginia averaged an additional 2.8 OIS victims per semester above what we would have normally expected had the law not changed (data not shown). Comparing the findings above from the ASCM + Fixed effect model to the other model specifications shows general agreement around the estimated ATT and level of significance for Idaho, Mississippi, Missouri, and West Virginia (Supplemental Table 28).

Supplemental Figs. 29 and 30 provide the overall ATT related to rates of nonfatal and fatal OIS violence separately. Notably, nonfatal and fatal violence displayed positive but nonsignificant relationships with Permitless CCW adoption. In addition, λ cross-validation figures for ASCM and ASCM + Fixed effects models are provided in Supplemental material (Supplemental Figs. 31–41).

Discussion

This article is the first to examine the relationship between CCW laws and fatal and nonfatal OIS violence. Our research introduces several important findings. Using Shall Issue states to construct policy counterfactuals indicated that adopting a Permitless CCW law resulted in additional OIS victimization. Using our data-drive approach, the ASCM + Fixed effect models provided the best pre-treatment counterfactuals to calculate the causal impact of Permitless CCW law adoption. These models displayed strong overall pre-treatment RMSE fit for 10 of the 11 treatment states, and we calculated an average of the ATT inverse weighted by the size of each model's jackknife standard error. We estimate that removing the need for a permit to carry a concealed weapon increased OIS victimization rates by 12.9%.

There has been much study of the impact of Shall Issue laws and RTC laws on firearm-related crime [26]. However, this study is among the first to examine the impact of moving from a Shall Issue CCW law to a Permitless CCW law. There is a growing need to examine the impact of moving from a Shall Issue CCW law to a Permitless CCW law on firearm-related crime. Evidence found here suggests there is likely an increase in rates of total OIS violence after Permitless CCW law adoption.

Less restrictive CCW laws may prompt increases public civilian gun carrying. Removal of the need for a permit eliminates economic costs associated with the permitting process and removes opportunity cost associated with obtaining the permit (e.g., time filling out paperwork, time spent at the police station, time on other requirements like live fire training, etc.). Those who found the economic cost and/or opportunity cost of obtaining a Shall Issue permit to high may choose to carry a concealed weapon in the absence of such requirement. Law enforcement might internalize this potential behavior change and increase the perceived risk of meeting an armed suspect or increase the number of calls for service for weapons complaints. Given that between 75 and 95% of homicides of law enforcement officers are committed with a firearm [44], it is plausible that less restrictive CCW laws can increase an officer's perceived risk of personal injury in an encounter which may in turn increase the likelihood that deadly force is used [45]. Prior research has found a relationship between state-level gun prevalence and OIS victimization [8]. Our findings are consistent with the theory that expanded access to firearms through lower restrictions for concealed carry increases both fatal and nonfatal OIS incidents.

This study is not without limitations. First, we acknowledge the limitations associated with the use of GVA data. While GVA data has been confirmed against other media-based data repositories of fatal OIS [9], and the use of media-based data collection for fatal OIS violence itself has been validated [46], the use of media reports to identify nonfatal shootings has not, and reporting of violence remains inherently biased. There is selection bias within the use of media reports in determining how much of a given outcome occurs due to publication bias. This is especially true for nonfatal shootings. A visual examination of Fig. 1 suggests that the number of victims fatal and nonfatal shot is similar from year to year. However, for violent crimes, particularly police involved violence, we hypothesize that the implicit "newsworthiness" of events is high; thus, we have reason to believe a reasonable valid capture of OIS violence through GVA and other media-based data repositories. Our decision to use fatal and nonfatal data is important as fatal violence data does not tell a complete story [47]. While not significant, it is notable that the direction of effect is similar when considering the disaggregated outcomes of fatal and nonfatal OIS violence rates compared to the total OIS violence rate direction. It may be that the use of fatal data alone is inadequate for examinations of potential policy determinants of OIS.

Another limitation of the GVA is that race/ethnicity is not readily available. While the inability to disaggregate our outcome by race/ethnicity does not bias our study's external validity to the population at large, it does pose additional questions about potential differential effects. Research has shown African Americans are disproportionately likely to be victims of a law enforcement officer involved shooting [48–51]. Due to our lack of data, we are unable to estimate whether the impact of CCW laws differs by the race/ethnicity of victims.

The use of ASCM + Fixed effects supplied the best available estimate of effect related to removing the permit requirement for who can legally carry a concealed weapon. However, the model's ability to successfully provide an accurate counterfactual is based on the likeness of donor pool states and pre-treatment fit between treated and control states. In the context of this study, we included 26 donor states that continuously issued Shall Issue CCW permits between 2014 and 2020. While the literature is currently unclear as to what qualifies as a "good" pre-treatment fit [52], the RMSE for 10 of the 11 states was small indicating the ATT produced from the comparison of the treated and synthetic states is valid (Fig. 5). Pre-treatment covariate averages were similar for the states with good pre-treatment fit among the ASCM + Fixed effect models (Supplemental Tables 2–13). Consider in tandem, strong RMSE and covariate balance suggest the ATTs were calculated using valid counterfactuals.

A primary robustness check for the SCM includes backdating or in-time placebo testing [53]. We were unable to conduct rigorous robustness checks due to limited pre-treatment data availability. In some instances, such as Kansas and Maine, there were only 4 pre-treatment periods, making in-time placebo testing not possible. This is a limitation of the data. To combat this limitation, we examined the extent to which the RMSE in the last 2 semesters during the pre-treatment period diverged from the RMSE overall. We argue that states with similar overall and divergent RMSE imply a consistent counterfactual better able to predict what would have happened in the treatment group had the policy not been adopted. The ASCM + Fixed effect model specification had strong overall RMSE with small divergence, indicating a robust prediction ability that was consistent across the pre-treatment period.

Conclusion

From 2014 to 2020, moving from a Shall Issue CCW law to a Permitless CCW law was associated with a 12.9% increase in the rate of OIS. Policy makers in Shall Issue CCW law states considering Permitless CCW law adoption and policy makers currently in Permitless CCW law states should consider the negative health consequences Permitless CCW laws.

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