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Banning open carry of unloaded handguns decreases firearm-related fatalities and hospital utilization

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ABSTRACT

Background Since 1967, in California it has been illegal to openly carry a loaded firearm in public except when engaged in hunting or law enforcement. However, beginning January 1, 2012, public open carry of unloaded handguns also became illegal. Fatal and non-fatal (NF) firearm injuries were examined before and after adoption of the 2012 ban to quantify the effect of the new law on public health.

Methods State-level data were obtained directly from California and nine other US state inpatient and emergency department (ED) discharge databases, and the Centers for Disease Control Web-Based Injury Statistics Query and Reporting System. Case numbers of firearm fatalities, NF hospitalizations, NF ED visits, and state-level population estimates were extracted. Each incident was classified as unintentional, self-inflicted, or assault. Crude incidence rates were calculated. The strength of gun laws was quantified using the Brady grade. There were no changes to open carry in these nine states during the study. Using a difference-in-difference technique, the rate trends 3 years preban and postban were compared.

Results The 2012 open carry ban resulted in a significantly lower incident rate of both firearm-related fatalities and NF hospitalizations ($p<0.001$). The effect of the law remained significant when controlling for baseline state gun laws ($p<0.001$). Firearm incident rate drops in California were significant for male homicide ($p=0.023$), hospitalization for NF assault ($p=0.021$ male; $p=0.025$ female), and ED NF assault visits ($p=0.04$). No significant decreases were observed by sex for suicides or unintentional injury. Changing the law saved an estimated 337 lives (3.6% fewer deaths) and 1285 NF visits in California during the postban period.

Discussion Open carry ban decreases fatalities and healthcare utilization even in a state with baseline strict gun laws. The most significant impact is from decreasing firearm-related fatal and NF assaults.

Level of evidence III, epidemiology.

INTRODUCTION

Gun violence in America claims the lives of over 32 000 persons per year or 88 per day,[1] with nearly 74 000 more experiencing non-fatal (NF) injuries.[2] Firearms are the second leading cause of injury-associated death.[2] It is estimated that over 300 million guns are owned in the USA, and we have the highest death rate from guns among all industrialized nations.[3 4] In 2016, seven physician societies in conjunction with the American Public Health Association and the American Bar Association (ABA) called for policies designed to "reduce the rate of firearm injuries and deaths in the United States."[3] The ABA inclusion is important as they are "committed to helping lawyers and the public understand that the Second Amendment does not impede reasonable measures to limit firearm violence."[3] Key to the policies is driving high-quality research to understand the components that contribute to gun violence and investigating strategies to address this public health emergency.

Despite being well recognized as a public health crisis,[5] the mechanisms to curb death and decrease injury from gun violence are controversial, with legislative approaches the most debated. Unfortunately, there has been a paucity of high-quality research since the Dickey Amendment (1996), which prohibited the Centers for Disease Control (CDC) from using federal funds to advocate for or promote gun control.[5 6] This ban was lifted in 2013 after several mass shootings,[6] and there has been a steady increase in the number of investigations. Although studies have shown that states with the most restrictive gun laws have lower homicide rates[1 3] and suicide rates,[7–9] it is not clear if further restricting laws on gun possession, including open carry, have additional benefits. In recent years, some states, including Texas (2015), have repealed bans on open carry, whereas others like California have strengthened bans.

Since 1967, in California it has been illegal to openly carry a loaded firearm in public except when engaged in hunting or law enforcement. However, beginning January 1, 2012, public open carry of unloaded guns also became illegal (California Penal Code 26350).[10] The aim of this study is to investigate the effect of the 2012 ban on open carry of unloaded firearms on fatal and NF firearm injuries using a difference-in-difference (DID) technique.[11]

METHODS

Data for 3 years preceding (2009, 2010, 2011) and following (2012, 2013, 2014) the law enactment were extracted from state-level publicly available data. Firearm case fatality numbers were obtained for California and nine other US states (Florida, Arizona, Oregon, Minnesota, Virginia, New York, Illinois, North Carolina, and Michigan) from the CDC Web-Based Injury Statistics Query and Reporting System (WISQARS).[12] These comparison states were chosen to constitute the "control" group as they had no significant changes to open carry or strength of gun laws during the study period. The strength of gun laws was quantified using the Brady grade categories[13] (A: California, New York; B: Illinois; C: Minnesota, Michigan; D: Oregon, Virginia; F: Florida, Arizona, North Carolina).

WISQARS data included classification as unknown intent, unintentional, self-inflicted, or violence-related (included assault/homicide/police intervention). Overall fatality rates represent all violence-related, suicides, and unintentional deaths. Subset analysis on only homicide was also performed. Data were extracted by sex, race, and year. Race is reported as white, black, Asian American, and Native American. Data were not available at the state level for categories with less than 10 persons. Due to low incidence numbers of Asian American and Native American, these two groups were combined ("Other"). Crude population and age-adjusted fatality rates were determined using the CDC state population stratified for sex. Rates were reported per 100 000 persons.

The CDC data do not contain information to allow state-specific comparisons of NF hospitalizations or emergency department (ED) visits. Therefore, state-level data were obtained from state inpatient databases, ED discharge databases, and vital statistics departments. Only California, Florida, and Minnesota report data consistent with the categorization of unintentional, self-inflicted, or assault/homicide stratified by sex and race. California data were provided by the California Department of Public Health Office of Statewide Planning and Development (ED and inpatient discharge databases). Florida data were obtained from the Department of Health Office, Injury Prevention Section (Agency for Health Care Administration, ED discharge and hospital discharge databases). Minnesota data were provided by the Department of Health Injury and Violence Prevention Unit Minnesota Injury Data Access System (MIDAS) reports.

Overall rate trends preban and postban were compared to determine if the 2012 law decreased fatalities and hospital visits using the DID technique with robust SEs (for clustering) and controlling for strength of gun laws (Brady grade). The DID model also controlled for difference in patient populations across the states (online supplementary etable 1), including sex, Hispanic ethnicity, and race. Age-adjusted rates were used to account for differences in distribution of age across states.

The DID is used to compare outcomes observed between groups over two time periods.[11] Groups should have no intervention exposure in the first period and satisfy the parallel trend assumption. During the second time period, the intervention exposure only occurs for the study group. The technique allows the estimation of the net outcome of an intervention over time through comparing the changes in a population that is exposed to the policy change with a population not exposed.[11]

The parallel trend assumption establishes that the trends in outcomes between treated and comparison groups must be the same preintervention. To assess this, linear regression was used to determine if the age-adjusted rate trends across the preintervention years were statistically different. Within each group, there was no difference (California $p=0.40$, control $p=0.73$). The difference between California and the control states during the preintervention period was also assessed and there was no difference ($p=0.21$). In addition, an analysis of the preintervention year-by-year trend by individual states was conducted and no state had a statistically significant difference at the $p<0.05$ level. Thus, the parallel assumption criteria were satisfied.

A sensitivity analysis of the DID analysis was performed to examine the effect of potential bias in the individual states that may have affected the results. First, the analysis was repeated given potential law changes postintervention in the state of New York could have affected the results. Next, any state with a preintervention year-to-year trend analysis with a $p<0.10$ was excluded to insure that small, but not statistically significant changes in the preintervention period year-to-year rates did not account for the net effect of the DID results. Arizona was the only state meeting this criteria. Finally, despite no statistically significant difference in the preintervention year-to-year trend lines for California, qualitative analysis is used commonly when assessing the parallel assumption trends. The rate in California from 2009 to 2010 appears visually to have decreased significantly. Given this visual assessment, the DID analysis was repeated excluding 2009.

To understand the impact of each type of fatal and NF injury on the overall rate changes, the trends in incidence rates over time were compared using linear regression. The percent change is based on the preintervention and postintervention periods using the preintervention as the baseline. Each time period average rate is calculated as the average during the 3 years. For example, the rate/100 000 is averaged for years 2009, 2010, and 2011 to provide the preintervention average rate. The percent change from baseline is then determined by (((postrate − prerate)/prerate)×100).

For crude rate estimates, the mean rate can be calculated as the average of the yearly estimates. For age-adjusted rates, yearly rates must account for the differences in populations during the time period. The average rate for a given category and time period was calculated by multiplying the age-adjusted rate by the population in that category for the specific year. The total for each year was summed together and then divided by the total population. This results in the average age-adjusted rate for the time period and is represented by (sum total (year-specific age-adjusted rate × year-specific population))/(sum total (population for the total time period)). The control group average age-adjusted rate was calculated similarly and represented by average age-adjusted rate=(sum total (state population × state-level age-adjusted rate))/(sum total (state population)).

To determine lives saved and visits avoided by the law, the average rates preintervention and postintervention were first calculated for case fatalities and visits. The preintervention rate was multiplied by the average population in the postperiod to determine the expected number of deaths (or visits) had no intervention occurred. This number was then compared with the actual observed number in the postperiod. The difference between the two represents the lives lost (or visits) that were avoided due to the legislative change. Statistical significance was determined at the $p<0.05$ level. All analyses were performed using STATA V.14.2.

RESULTS

The DID analysis demonstrated NF hospital admissions and overall fatalities attributed to firearm injury decreased in California compared with the control states after the enactment of the open carry ban (table 1).

Total hospital utilization (ED outpatient visits and NF hospitalizations) resulted in an age-adjusted rate of 17.24 injuries per 100 000 persons in the preban time period compared with 16.16 per 100 000 persons postban. The largest decrease was seen in NF hospitalizations, with a relative decrease from the preban period of 9.30% (table 1). In contrast, the rate of hospitalization fell only 1.23% in the non-intervention group ($p<0.001$). There was no statistical difference between the two groups in the rate of NF ED outpatient visits.

The DID analysis controlling for strength of gun laws, sex, race, and ethnicity also demonstrated the ban resulted in a significantly lower incidence of firearm-related fatalities (figure 1; $p<0.001$; online supplementary etable 2). Excluding deaths from unknown intent and legal intervention, the crude

Table 1 Healthcare utilization and fatalities from firearm injuries

	California		Other states		% change		P values
	Pre	Post	Pre	Post	California	Other	
Crude rates							
NF visits*							
ED visit only	9.29	8.92	8.80	8.25	−3.98	−6.25	0.824†
Hospitalization	7.96	7.23	5.60	5.66	−9.17	+1.07	<0.001†
Total NF visits	17.26	16.14	14.55	14.21	−6.49	−2.34	0.706†
Fatalities	8.07	7.85	10.21	10.43	−2.73	+2.15	<0.001†
Fatalities‡	7.83	7.55	10.02	10.21	−3.58	+1.90	<0.001†
Age-adjusted rates							
NF visits*							
ED visit only	9.27	8.94	11.00	11.88	−3.56	+8.00	0.821†
Hospitalization	7.96	7.22	8.13	8.03	−9.30	−1.23	<0.001†
Total NF visits	17.24	16.16	19.14	19.91	−6.26	+4.02	0.704†
Fatalities	7.90	7.64	9.54	9.58	−3.29	+0.42	0.003†
Fatalities‡	7.67	7.35	9.35	9.38	−4.17	+0.32	0.001†

Rates per 100 000 persons.
*"Other states" used as the controls for NF visits include only Florida and Minnesota.
†Difference-in-difference analysis comparing California with the other states controlling for race, sex, strength of state gun laws, and Hispanic status.
‡Excludes death from unknown intent and legal intervention.
ED, emergency department; NF, non-fatal.

case fatality rates decreased 3.6% in California, whereas the rate rose 1.9% in the controls (table 1; p<0.001). Similarly, the age-adjusted case fatality rate decreased 4.17% in California while rising 0.32% in the controls (table 1; p<0.001; online supplementary etable 3). Changing the law saved an estimated 337 lives in California (3.6% fewer deaths) and 1285 NF visits during the postban period (table 1).

Sensitivity analysis

For the DID analysis of the age-adjusted case fatality rates, a sensitivity analysis was conducted to account for potential confounders that could have affected the results. First, New York, which had some minor law changes in the postintervention period, was excluded. The effect of the DID analysis remained unchanged (p=0.002). Next, Arizona was excluded from the analysis given potential violation of the parallel trend assumption as the state-specific year-to-year trend rate had a p<0.1. The DID analysis remained with a significant difference between California and the control states (p=0.028). Finally, given the visual assessment of the rates in California appeared to show a potential decrease in case fatality rates from year 2009 to 2010 (indicating a potential parallel trend assumption violation), the analysis was repeated excluding 2009 for all states. The DID results remained significant (p=0.042).

The role of injury intent

The intent to harm through firearm assault had the largest decrease in California hospital utilization (10.16% decrease; preban age-adjusted rate 12.11 visits/100 000 persons vs. 10.88 postban, p=0.022; table 2).

Although the absolute rate also fell in the controls, this small decrease within group yearly trend was not statistically

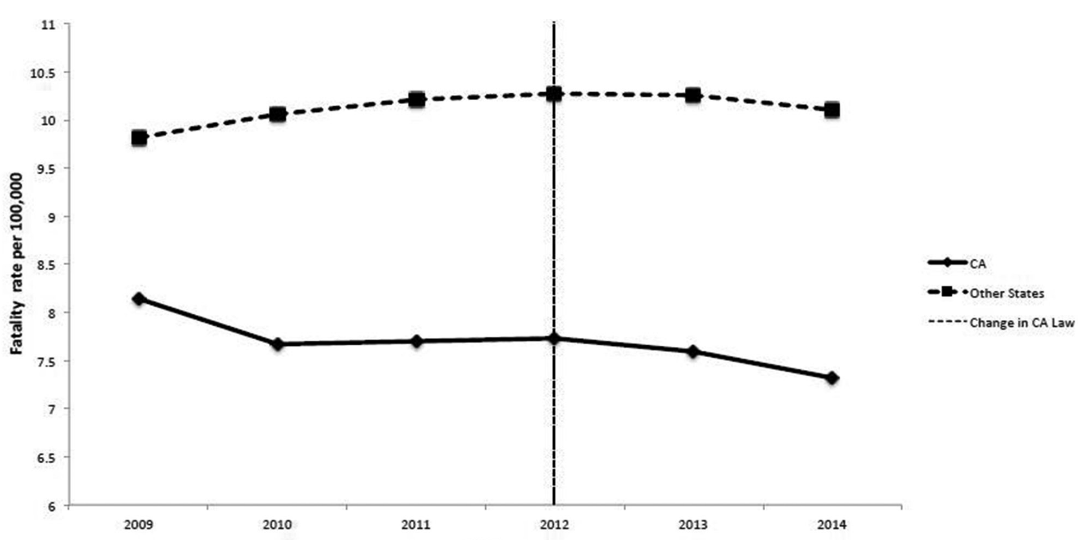

Figure 1 Case fatality rates preintervention and postintervention. CA, California.

Table 2 Injuries by intent between California and the control states

Intent	Type	California 2009–2011	California 2012–2014	California P values	Other states 2009–2011	Other states 2012–2014	Other states P values	California vs. other states P values*
Crude rates								
NF visits†	Assault	12.12	10.87	0.02	7.22	6.79	0.23	0.004
	Suicide attempt	0.36	0.36	0.71	0.53	0.45	0.14	<0.002*
	Unintentional	4.79	4.95	0.91	6.79	6.96	0.83	0.760
Fatalities	Homicide	3.68	3.39	0.012	3.36	3.23	0.612	0.333
	Suicide	4.09	4.09	0.871	6.53	6.86	0.507	<0.001
	Unintentional	0.07	0.08	1.000	0.13	0.11	0.649	0.546
Age-adjusted rates								
NF visits†	Assault	12.11	10.88	0.022	9.20	8.53	0.728	0.010
	Suicide attempt	0.35	0.36	0.785	0.63	0.54	0.568	0.001
	Unintentional	4.77	4.92	0.862	7.66	9.43	0.964	0.740
Fatalities	Homicide	3.56	3.32	0.026	3.69	3.56	0.676	0.709
	Suicide	4.04	3.94	0.052	5.55	5.74	0.627	<0.001
	Unintentional	0.071	0.073	0.737	0.15	0.14	0.781	0.409

Rates per 100 000 persons.
*Difference-in-difference analysis comparing California with the other states controlling for race, sex, strength of state gun laws, and Hispanic status.
†"Other states" used as the controls for NF visits include only Florida and Minnesota.
NF, non-fatal.

significant (p=0.728). To determine if the rate change in California was statistically different from the controls, a DID analysis controlling for strength of gun laws, sex, race, and ethnicity was performed. The rate of NF assault in California was significantly decreased compared with the controls (p=0.010; table 2). Similarly, a decrease in homicide rate was the largest driver of decreased firearm fatalities in California (table 2). The California homicide rate was 6.74% lower in the postban era (p=0.026), whereas the rate in the controls only fell 3.52% (p=0.67). However, when comparing between-group differences, the rate of change was not statistically different (table 2).

The rates of NF suicide attempts and unintentional injury demonstrated no statistical within-group difference in either California or the controls (table 2). However, in comparing California with the controls, there was a statistically significant difference in suicide attempts, with a slight fall in the control states compared with essentially no change in California (table 2; p=0.001). Unfortunately, this lower rate of NF suicide attempts in the control group is tempered by the finding that there was a rise in the rate of lives lost in the same time period as the result of suicide. Thus, postban the net effect was a decrease in lives lost within California from suicide compared with the control states (p<0.001; table 2).

Impact of sex

Hospitalization for NF assault (p=0.021 male; p=0.025 female) and ED NF assault visits (total p=0.04; p=0.035 male; p=0.114 female) both dropped after the law enactment. The rates of suicide and unintentional injury remained stable (table 3).

For men, the rate of suicide was no different (7.59 preban, 7.40 postban; p=0.061) and unintentional injury was uncommon (0.12 preban and 0.13 postban; p=0.646). Female suicide rates also remained stable (0.89 preban and postban) and unintentional injury was extremely rare (0.02 preban and postban).

For violence-related deaths, both male and female rates trended down. Male homicide rates dropped from 6.97 per 100 000 to 5.85 per 100 000 for a relative decrease of 16.1% (p=0.02). There was also a proportional decrease in female homicide rates by 7.87% (0.89 preban and 0.82 postban). During the 6-year study, the female homicide rate dropped from 0.87 per 100 000 in 2009 to 0.78 per 100 000 in 2014, but this trend did not reach statistical significance (p=0.077). This likely reflects the low overall case numbers in women.

The role of race on fatalities was also examined stratified by sex. The law appeared to have the most significant effect on white, male homicide rates (table 4).

Whereas this group saw a 9.20% drop in case fatality rates (p=0.01), black men only had a 1.56% drop (p=0.27) after the ban. The rate of black male homicide remains dauntingly high with a case fatality rate of 30.21 per 100 000 compared with a rate of only 4.64 per 100 000 in white men. Although overall the number of affected women is much lower, proportionally, black women still suffer homicide at a rate fourfold higher than white women (table 4).

DISCUSSION

Firearm injury is a public health crisis in the USA claiming more than 300 000 persons in the last decade and injuring far more.[1 2 4 14] The annual estimated cost of injuries exceeded $174 billion in 2010[3] and NF injuries are 40 times more common than fatal injuries.[14] Despite small decreases, the incidence of gun violence still far outpaces other nations.[3 4 14] Australia adopted a panel of strict gun laws in 1996 after a mass shooting.[15 16] As a result, the case fatality rate is now 134 times smaller than in the USA despite only a 13.7-fold population difference.[15 16] Likewise, firearm-related homicide is 27 times higher in the USA.[15 16]

The underlying causes are a complicated, multifaceted issue that spans cultural, economic, behavioral including substance abuse, firearm safety, and legislative factors that contribute to the staggering statistics.[2 15 17] Although no single law is likely to have an overwhelming effect, continuing to assess and implement strategies that contribute to driving this rate down is a key principle for curbing this public health emergency. Even former Representative Jay Dickey, the author of the amendment

Table 3 California firearm case fatality rates by year for violence-related*, suicide, and unintentional injury

	Crude rates			Age-adjusted rates		
Rate/100 000 persons	Violence-related	Unintentional	Suicide	Violence-related	Unintentional	Suicide
2009						
Male	7.37	0.16	7.31	6.97	0.15	7.69
Female	0.88	0.02	0.90	0.87	0.02	0.88
Total	4.13	0.09	4.11	4.02	0.08	4.10
2010						
Male	6.67	0.11	7.10	6.26	0.11	7.44
Female	0.91	0.02	0.94	0.90	0.02	0.90
Total	3.77	0.06	4.00	3.64	0.06	3.97
2011						
Male	6.54	0.11	7.39	6.18	0.11	7.65
Female	0.91	0.02	0.95	0.89	0.02	0.89
Total	3.71	0.06	4.15	3.59	0.07	4.06
2012						
Male	6.93	0.14	7.28	6.60	0.13	7.50
Female	0.86	0.02	0.91	0.87	0.02	0.87
Total	3.88	0.08	4.07	3.79	0.08	3.99
2013						
Male	6.55	0.16	7.26	6.30	0.15	7.38
Female	0.84	0.02	0.98	0.82	0.02	0.92
Total	3.68	0.09	4.09	3.61	0.09	3.95
2014						
Male	6.09	0.10	7.24	5.85	0.10	7.32
Female	0.76	0.02	0.96	0.78	0.02	0.88
Total	3.41	0.06	4.08	3.36	0.06	3.90

*Violence-related data include death resulting from police intervention and homicides.

banning gun violence research, has evolved to state that funding is needed and that "doing nothing is no longer an acceptable solution."[6]

This study examines the role of legislative action on injuries through expanded restriction of open carry laws. California has the strongest gun laws, ranking highest on the Brady scale in the nation with 104 separate laws.[13 18 19] The impact of open carry laws on firearm injuries had not previously been investigated. Demonstrating the expansion of the open carry law had a measurable effect on decreasing firearm death and injury in a state already with the most restrictive gun regulations in the nation suggests that this type of gun control measure has incremental added benefit.

The ABA and multiple physician stakeholder groups have jointly advocated for both increased research and regulations.[3 20] To be accepted, legislation must respect the second amendment, be rational in implementation, and based on fundamentally sound research. Fatality rates are lower in states that have more restrictive overall gun laws.[21–23] However, simply having more laws is not the answer[22]; uncovering which specific laws actually make a difference is important for both public safety and advocacy efforts. For example, the ban on open carry had only a small effect on suicide rates and this is not surprising. Overall access to guns is a far more important factor in suicide prevention.[1 24 25]

California also has a sizeable number of gun owners with over 2.9 million handguns purchased in the last 9 years, with men having the highest rate at 242 handguns per 10 000 persons compared with a rate of 25 per 10 000 for women.[1] There is also racial differences (white: 209 per 10 000; black: 80 per 10 000[1 26]). Multiple studies have shown that firearm ownership is a risk factor for both suicide and homicide.[1 3 7–9 19 27 28] Interestingly, the largest reduction in firearm fatalities and hospital utilization in this study was seen in white men. This suggests that this law was particularly effective in this subgroup.

Homicide and NF injury disproportionately affect black men and women.[14 22 29] The case fatality rate was greater than fourfold higher in both black men and women compared with white men and women, respectively. Unfortunately, the implementation of the open carry ban on unloaded guns had minimal effect on blacks. Although only speculative, this further highlights that there are likely differing risk factors across racial groups, making subgroup analyses of legislative changes extremely important.

Although suicide makes up the largest proportion of firearm deaths, those from homicide have fueled the debate on tougher gun control legislation. As mass shootings have become more common, the debate over gun control has found renewed visibility.[28] The reality is that the number of persons killed or injured each year is astronomically higher from interpersonal violence than from mass shootings. In fact, mass shootings make up less than 1% of all firearm deaths.[1] Contributing to the controversy is a lack of literature examining the specific impact of the new legislation.

The DID regression analysis is a commonly employed strategy in health policy research when assessing the longitudinal outcomes after changes in legislation.[11] Research approaches that compare outcomes with differing state gun laws can be biased by the multitude of causative factors affecting gun violence that are not able to be controlled for in the analyses.[18] Reporting before

Table 4 California case fatality* rates by sex and race

Intent	Year	Crude rates White	Crude rates Black	Crude rates Other	Age-adjusted rates White	Age-adjusted rates Black	Age-adjusted rates Other
Male							
Homicide	2009	5.52	32.99	2.66	5.28	29.14	2.45
	2010	4.97	30.77	1.80	4.69	27.90	1.65
	2011	4.85	28.32	2.15	4.63	25.44	2.02
	2012	4.97	30.53	2.17	4.79	27.99	1.93
	2013	4.72	30.53	1.66	4.60	27.75	1.55
	2014	4.24	29.56	1.88	4.15	26.94	1.73
	Pre	5.11	30.69	2.20	4.87	27.47	2.02
	Post	4.64	30.21	1.90	4.51	27.56	1.74
	% change	−9.20	−1.56	−13.63	−7.39	+0.33	−13.86
	P values	0.01	0.27	0.17	0.03	0.45	0.16
Suicide	2009	8.44	4.23	2.73	8.82	4.75	2.70
	2010	8.42	3.95	2.27	8.69	4.53	2.27
	2011	8.79	4.36	2.25	8.98	4.54	2.24
	2012	8.66	3.96	2.36	8.81	4.26	2.34
	2013	8.66	4.38	2.16	8.70	4.44	2.12
	2014	8.71	3.68	2.21	8.70	4.15	2.16
	Pre	8.55	4.18	2.42	8.83	4.60	2.39
	Post	8.68	4.01	2.24	8.73	4.28	2.20
	% change	+1.52	−4.07	−7.44	−1.13	−6.96	−7.95
	P values†	0.13	0.48	0.10	0.50	0.02	0.07
Female							
Homicide	2009	0.70	3.21	0.59	0.69	2.99	0.56
	2010	0.80	3.34	0.37	0.80	3.15	0.35
	2011	0.82	2.52	0.60	0.81	2.44	0.54
	2012	0.62	3.44	0.76	0.63	3.31	0.74
	2013	0.74	2.21	0.58	0.72	2.07	0.56
	2014	0.65	2.54	0.33	0.67	2.46	0.35
	Pre	0.77	3.02	0.52	0.76	2.86	0.48
	Post	0.67	2.73	0.56	0.68	2.61	0.54
	% change	−12.99	−9.60	+7.69	−10.53	−8.74	−12.50
	P values†	0.41	0.21	0.75	0.50	0.25	0.87
Suicide	2009	1.08	NA	NA	1.04	NA	NA
	2010	1.11	NA	NA	1.05	NA	NA
	2011	1.13	NA	NA	1.06	NA	NA
	2012	1.10	NA	NA	1.04	NA	NA
	2013	1.23	NA	NA	1.16	NA	NA
	2014	1.21	NA	NA	1.11	NA	NA
	Pre	1.11	NA	NA	1.05	NA	NA
	Post	1.18	NA	NA	1.10	NA	NA
	% change	+6.31	NA	NA	+4.76	NA	NA
	P values†	0.03	NA	NA	0.10	NA	NA

Rates per 100 000 persons.
*Unintentional case fatality not reported as numbers by race are not sufficient for the Centers for Disease Control to legally disclose.
†Linear regression of trend line for changes in rates across years for the given race and sex category.
NA, not available.

and after results in the intervention group would not be sufficient to draw conclusions as there are multiple other unmeasured confounders that could have effective changes in case numbers.

The DID is a robust alternative method for overcoming these potential biases, and any differences found between groups are interpreted as being a causal effect of the policy.[11] This technique is particularly important when observational studies or randomized control trials are not available. The findings are most helpful when comparison groups are large and the data span enough time to see the longitudinal impact of a legislative change.[18] This study included a large number of states in the control group with differing overall strength of gun laws and used multiyear data. This provided enough observations and statistical power to uncover important differences in case fatality rates and hospitalization usage.

The DID also relies on two key assumptions. The first assumption is parallel trends. The trends in outcomes between the treated and comparison groups must be the same prior to the intervention. If they are not, the DID cannot be used. Regression modeling was used to determine if the trends are statistically different across the years of the preintervention. There was no statistically significant difference in trends in the preintervention period within or between groups. In the sensitivity analysis, the results remained statistically significant, supporting the difference seen was not attributable to a violation of the parallel trend assumption.

The second key assumption is that of "common shocks assumptions." This assumption states "that any events occurring during or after the time of the policy changed will equally affect the treatment and comparison groups."[30] These are considered unexpected and unpredictable events that are unrelated to the policy.[30] In our study time period, there was several highly visible events in the USA involving firearms, including the Fort Hood shooting (Texas 2009), Binghamton shootings (New York 2009), the Geneva county shooting (Alabama 2009), the Sandy Hook Elementary School shooting (Connecticut 2012), the Aurora Theater shooting (Colorado 2012), and the Washington Naval Yard shooting (DC 2013).

There is no plausible reason to think that the control or treatment groups would have been differentially affected by these events which were widely carried on national news coverage. However, it is acknowledged that there could be unaccounted variables that changed over time that could not be measured or controlled for that differentially affected a control state. The DID analysis is strongest when control groups are as large as possible to minimize the effect of this unknown "common shock." Therefore, the control group includes all the states with stable gun laws during the study period.

The 2012 ban on open carry resulted in a significant decrease in both firearm-related fatalities and hospital utilization. Changing the law led to 3.7% less fatalities and 6.5% fewer hospital visits in California. This translates to 337 saved lives and 1285 fewer hospital visits. Although these decreases are modest, extrapolated nationwide, this would represent almost 1200 fewer deaths per year and over 4800 fewer costly hospital visits. Although the data demonstrate the net effect of banning open carry was a reduction in fatalities and hospital utilization, the vast majority of this effect was from the decrease in assaults. During the last 20 years, efforts have been under way, including legislative actions, to curb loss of life from interpersonal gun violence. These data suggest that these legislative actions have an effect on at least a portion of the intended at-risk groups, but that effect varies by race.

This study has several limitations. The most significant is the limited number of Brady grade A states with no changes to open carry during the study period. New York had no appreciable change in their Brady grade, but did enact a controversial law, the Secure Ammunition and Firearms (SAFE) Act, during 2013. This law was widely challenged in court and was not settled until 2015. The act contained multiple provisions including the ban on assault weapons and expanded background checks, and made internet sales of ammunition illegal. Although there was no change in Brady grade, the inclusion of New York in the controls could have affected our results; however, it would be expected to bias the results toward the null as these provisions strengthened laws. We also performed a sensitivity analysis without New York in the controls. The DID analysis remained significant ($p=0.002$) and the net effect of the difference in fatality rates between California and the control states was even greater. Therefore, we think that our inclusion of New York provides a conservative estimate of the net effect of the ban on open carry.

Further limitations include the small number of states reporting data for NF injuries in publicly available data sets. The control group for these analyses relies on only two comparison states. Although this is considered an adequate sample size in a DID analysis, the limited variety of the included states could have biased the results. Additionally, the categorization of race is limited to only white, black, and other due to the restrictions in reporting for CDC data. Finally, case numbers are quite small, especially for women by race categories, making reporting relative changes somewhat misleading. Large relative changes can be seen for incidence rates with quite small absolute changes.

CONCLUSIONS

Open carry ban decreases fatalities and healthcare utilization even in a state with baseline strict gun laws. The most significant impact is from decreasing firearm-related fatal and NF assaults.

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