

# State Level Firearm Concealed-Carry Legislation and Rates of Homicide and Other Violent Crime

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- BACKGROUND:** Over the last 30 years, public opinion and state level legislation regarding the concealed-carry of firearms have shifted dramatically. Previous studies of potential effects have yielded mixed results, making policy recommendations difficult. We investigated whether liberalization of state level concealed-carry legislation was associated with a change in the rates of homicide or other violent crime.
- STUDY DESIGN:** Data on violent crime and homicide rates were collected from the US Department of Justice Uniform Crime Reporting Program (UCR) and the Centers for Disease Control and Prevention (CDC) over 30 years, from 1986 to 2015. State level concealed-carry legislation was evaluated each study year on a scale including “no carry,” “may issue,” “shall issue,” and “unrestricted carry.” Data were analyzed using general multiple linear regression models with the log event rate as the dependent variable, and an autoregressive correlation structure was assumed with generalized estimating equation (GEE) estimates for standard errors.
- RESULTS:** During the study period, all states moved to adopt some form of concealed-carry legislation, with a trend toward less restrictive legislation. After adjusting for state and year, there was no significant association between shifts from restrictive to nonrestrictive carry legislation on violent crime and public health indicators. Adjusting further for poverty and unemployment did not significantly influence the results.
- CONCLUSIONS:** This study demonstrated no statistically significant association between the liberalization of state level firearm carry legislation over the last 30 years and the rates of homicides or other violent crime. Policy efforts aimed at injury prevention and the reduction of firearm-related violence should likely investigate other targets for potential intervention. (*J Am Coll Surg* 2018;■:1–8. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)
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Public interest regarding violence and its specific association with firearms is currently high. Previous reports have provided in depth analyses and determined factors that

were associated with firearms and violent crime and homicide; however, these results of different studies have been inconsistent, even diametrically opposite.<sup>1-4</sup> Although such inconsistent findings seem impossible, much of the reason may lie in the details of the statistical analysis used in the various studies. Although much research on this topic has been done, many are concerned that large scale efforts are hampered by federal legislation, which holds that the US Centers for Disease Control and Prevention and National Institutes of Health funding could not be used to “advocate or promote gun control.”<sup>5</sup> Due to the interpretation and implementation of this legislation, federal funding for research efforts into firearms violence can be difficult to obtain.

In the US, the right to bear arms is guaranteed by the Second Amendment to the Constitution and has been

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construed by the US Supreme Court in the landmark case *District of Columbia v Heller* as a fundamental individual right.<sup>6</sup> However, the *Heller* decision also made it clear that this right can be subject to limitations including restricting the possession of firearms by felons and persons with certain forms of mental illness. An unresolved constitutional question remains the carrying of firearms by civilians outside the home. Both legal review and public opinion remain significantly divided on this issue.

Despite the controversy, state level concealed-carry laws are becoming more prevalent,<sup>7</sup> and by a conservative estimate, more than 16.3 million Americans have permits to carry concealed firearms.<sup>8</sup> Proponents of concealed-carry cite associations with decreasing crime<sup>2</sup> and the widespread defensive use of firearms.<sup>9</sup> Opponents raise issues such as the potential for increased crime by those carrying weapons,<sup>10</sup> and associations with increased homicide rates.<sup>4</sup>

Given the inconsistency of previous studies and the continued shift toward more liberal state concealed-carry legislation, we investigated whether liberalization of state level concealed-carry legislation was associated with a change in the rates of homicide or other violent crime using a rigorous statistical method that would more accurately capture the precision of the estimated association. We hypothesized that there would be no association between the rates of homicide or other violent crimes and changes in state level concealed-carry legislation status. Realizing these objectives would illuminate areas for future research as well as meaningfully contribute to current public discourse.

## METHODS

This was a retrospective analysis of national and publicly available data that made use of changes in state-level concealed-carry legislation during the study period. The aim was to assess the relationship between legislative status and the firearm-related homicide and violent crime rates nationally during the period of 1986 to 2015—a period during which a dramatic change in state level concealed-carry legislation took place. This study was reviewed by the Institutional Review Board of the Mayo Clinic and determined not to constitute human subjects research because it uses only publicly available, de-identified data.

### Databases used

For the years from 1986 to 2015, data regarding concealed-carry legislation, crime rates, and public health statistics were collected from a variety of publicly available sources including the US Department of Justice Uniform Crime reporting system, and the US CDC and

Prevention Web-Based Injury Statistics Query and Reporting System. We obtained data concerning potential confounders, specifically, poverty and unemployment rates, from the US Census Bureau and US Department of Labor Bureau of Labor Statistics.

State-level legislation regarding civilian concealed-carry was examined from all 50 states and the District of Columbia for each year over the study period. Changes in legislative status were considered to have occurred in the year the legislation was enacted. Data were obtained from a variety of different sources including text of state legislation, previous publications,<sup>11</sup> and media and internet sources.<sup>12</sup> The restrictiveness of state concealed-carry legislation was divided into 4 broad categories: No Carry, in which no mechanism exists for legal civilian concealed-carry of firearms; May Issue, in which a mechanism exists for issuance of concealed-carry permit, but the process is subject to the discretion of issuing authority and may be arbitrarily denied in some jurisdictions; Shall Issue, in which a concealed-carry permit must be issued unless a disqualification exists; and Constitutional or Unrestricted Carry, in which concealed-carry is allowed without a permit unless a disqualification exists. This was analyzed as an ordinal scale (1 to 4). To allow for further binary analysis, concealed-carry legislative restrictions were also considered in two broad groups: Restrictive (encompassing No Issue and May Issue) and Non-Restrictive (Shall Issue and Unrestricted Carry).

Data on state-level crime were obtained from the US Department of Justice Uniform Crime Reporting (UCR) program.<sup>13</sup> The UCR program, established in 1929, collects information on crimes reported to law enforcement agencies for a variety of violent and nonviolent crime categories including murder, rape, robbery, aggravated assault, burglary, and larceny. Crime data were obtained on overall violent crime, murder, rape, robbery, aggravated assault, and overall nonviolent crime for each state and the District of Columbia for each year of the study period.

Specific public health data regarding homicide and firearm homicide rates were obtained from the Centers for Disease Control and Prevention (CDC) Web-Based Injury Statistics Query and Reporting System.<sup>14</sup> State level data regarding homicides and firearm homicides were collected for each state and the District of Columbia for each year of the study period.

To account for major societal factors that could act as confounders for any effect, we also examined rates of poverty and unemployment, two well described factors known to influence crime.<sup>15-17</sup> Yearly poverty data for each state were obtained from the US Census Bureau.<sup>18</sup> Unemployment statistics over the study period were

obtained from the US Department of Labor Bureau of Labor Statistics.<sup>19</sup>

### Statistics

Data were analyzed in SAS (SAS Institute Inc) using general multiple linear regression models, with Y being the log of the event rate and fitting main effects for each unique state and year. In this way, each state acted as its own control, ie, only deviations from within-state averages. Furthermore, the overall trends in crime rates that were consistent across states were filtered out by the removal of the “year” main effects. This allowed analysis of state-to-state variation in the timing and extent of legislative status changes insofar as these influenced the yearly deviations of each state from the overall trends. Legislative status, the primary predictor variable of interest, was analyzed both as a scale (No Issue, May Issue, Shall Issue, and Unrestricted), and as a binary variable nonrestrictive (Shall Issue or Unrestricted Carry) vs restrictive (May Issue or No Carry).

To allow for nonindependence among the serial observations within a state, an autocorrelation structure was implemented with a generalized linear model (GENMOD procedure in SAS) using generalized estimating equations (GEE) estimates for standard errors. The standard errors obtained were approximately twice as large as those assuming independence, demonstrating the importance of allowance for this autocorrelation structure. In effect, nearby years for a given state do not provide independent information on the effect of that state’s legislative status.

### RESULTS

Over the 30-year period between 1986 and 2015, complete data on 14 variables for each state and year were available. Variables for analysis included carry legislation scale (1 to 4), binary carry restrictions, UCR homicide rate, UCR violent crime rate, UCR rape rate, UCR robbery rate, UCR aggravated assault rate, UCR burglary rate, CDC homicide rate, CDC firearm homicide rate, unemployment rate, and poverty rate. Complete data were available for all states and the District of Columbia. This resulted in 21,420 discrete data points for analysis.

During the study period, there was a dramatic shift in state level concealed-carry legislation, with a trend toward less restrictive legislation (Table 1). By the end of the study period, all states had adopted legislation allowing civilian concealed-carry in some form. At the beginning of the study period in 1986, 42 states (82.4%) had significant restrictions on civilian concealed-carry, with 16 states (31.4%) not allowing it whatsoever. However, by

2015, all states had at least some mechanism to allow civilian concealed-carry in place, with 42 states (82.4%) either requiring issuance of concealed-carry permits or allowing unrestricted carry except for disqualified individuals.

The results of our regression analysis considering the scale of concealed-carry legislation are summarized in Table 2. When adjusted for state and year, the association between the scale level of carry legislation permissiveness and all UCR crime rates analyzed was not significant for any variable including homicide ( $p = 0.96$ ), violent crime ( $p = 0.44$ ), rape ( $p = 0.46$ ), robbery ( $p = 0.14$ ), aggravated assault ( $p = 0.77$ ), and burglary ( $p = 0.78$ ). Similarly, when examining CDC public health data, associations were not significant for either homicides ( $p = 0.16$ ) or firearm homicides ( $p = 0.30$ ). When adjusting for poverty and unemployment, small changes were seen in the regression results. For example, the unadjusted CDC homicide regression coefficient was  $0.0330 \pm 0.0233$ , such that every level of permissiveness was associated with a 3.3% higher rate. When additionally adjusted for poverty rate and unemployment rate, the effect was  $3.1\% \pm 2.4\%$  ( $p = 0.19$ ).

Table 3 summarizes the results when analyzing the level of carry legislation permissiveness as the binary variable restrictive vs nonrestrictive. When adjusted for state and year, the association between the binary carry legislation permissiveness and all UCR crime rates and CDC public health data analyzed was not significant for any variable including homicide ( $p = 0.92$ ), violent crime ( $p = 0.33$ ), rape ( $p = 0.96$ ), robbery ( $p = 0.17$ ), aggravated assault ( $p = 0.51$ ), burglary ( $p = 0.85$ ), CDC homicide ( $p = 0.23$ ), and CDC firearm homicide ( $p = 0.19$ ).

Further adjustments for poverty and unemployment slightly changed the regression coefficients. Again, using CDC homicide as an example, the unadjusted effect was  $4.41\% \pm 3.7\%$  ( $p = 0.23$ ), and when further adjusted for poverty and unemployment, was  $4.2\% \pm 3.7\%$  ( $p = 0.26$ ). Overall, there was no statistically significant association for any tested crime or public health variable with a change in the level of concealed-carry legislation restrictiveness either as a scale or binary variable. In addition, although small changes in the regression coefficients were noted, additional adjustments for either poverty or unemployment did not significantly affect the outcome for any data point.

### DISCUSSION

Firearms violence and gun control are highly publicized and politicized in US society today. From the widespread media attention related to mass shootings, to the

**Table 1.** State Level Concealed-Carry Legislation by Year

| Year | No carry | May issue | Shall issue | Unrestricted carry | Restrictive legislation, n (%) | Nonrestrictive legislation, n (%) |
|------|----------|-----------|-------------|--------------------|--------------------------------|-----------------------------------|
| 1986 | 16       | 26        | 8           | 1                  | 42 (82.4)                      | 9 (17.6)                          |
| 1987 | 16       | 25        | 9           | 1                  | 41 (80.4)                      | 10 (19.6)                         |
| 1988 | 16       | 25        | 9           | 1                  | 41 (80.4)                      | 10 (19.6)                         |
| 1989 | 15       | 22        | 13          | 1                  | 37 (72.5)                      | 14 (27.5)                         |
| 1990 | 14       | 21        | 15          | 1                  | 35 (68.6)                      | 16 (31.4)                         |
| 1991 | 14       | 20        | 16          | 1                  | 34 (66.7)                      | 17 (33.3)                         |
| 1992 | 14       | 20        | 16          | 1                  | 34 (66.7)                      | 17 (33.3)                         |
| 1993 | 14       | 20        | 16          | 1                  | 34 (66.7)                      | 17 (33.3)                         |
| 1994 | 13       | 18        | 19          | 1                  | 31 (60.8)                      | 20 (39.2)                         |
| 1995 | 9        | 14        | 27          | 1                  | 23 (45.1)                      | 28 (54.9)                         |
| 1996 | 8        | 12        | 30          | 1                  | 20 (39.2)                      | 31 (60.8)                         |
| 1997 | 8        | 12        | 30          | 1                  | 20 (39.2)                      | 31 (60.8)                         |
| 1998 | 8        | 12        | 30          | 1                  | 20 (39.2)                      | 31 (60.8)                         |
| 1999 | 8        | 12        | 30          | 1                  | 20 (39.2)                      | 31 (60.8)                         |
| 2000 | 8        | 12        | 30          | 1                  | 20 (39.2)                      | 31 (60.8)                         |
| 2001 | 8        | 11        | 31          | 1                  | 19 (37.2)                      | 32 (62.7)                         |
| 2002 | 8        | 11        | 31          | 1                  | 19 (37.2)                      | 32 (62.7)                         |
| 2003 | 6        | 9         | 34          | 2                  | 15 (29.4)                      | 36 (70.6)                         |
| 2004 | 5        | 9         | 35          | 2                  | 14 (27.5)                      | 37 (72.5)                         |
| 2005 | 3        | 9         | 37          | 2                  | 12 (23.5)                      | 39 (76.4)                         |
| 2006 | 3        | 9         | 37          | 2                  | 12 (23.5)                      | 39 (76.4)                         |
| 2007 | 3        | 9         | 37          | 2                  | 12 (23.5)                      | 39 (76.4)                         |
| 2008 | 3        | 9         | 37          | 2                  | 12 (23.5)                      | 39 (76.4)                         |
| 2009 | 3        | 9         | 37          | 2                  | 12 (23.5)                      | 39 (76.4)                         |
| 2010 | 3        | 9         | 36          | 3                  | 12 (23.5)                      | 39 (76.4)                         |
| 2011 | 2        | 8         | 37          | 4                  | 10 (19.6)                      | 41 (80.4)                         |
| 2012 | 2        | 8         | 37          | 4                  | 10 (19.6)                      | 41 (80.4)                         |
| 2013 | 1        | 8         | 37          | 5                  | 9 (17.6)                       | 42 (82.4)                         |
| 2014 | 0        | 9         | 37          | 5                  | 9 (17.6)                       | 42 (82.4)                         |
| 2015 | 0        | 9         | 35          | 7                  | 9 (17.6)                       | 42 (82.4)                         |

increasing number of media reports of defensive use of firearms, the exact role of firearms in our society is widely debated. Over the past 10 years, CDC data continue to demonstrate that unintentional injury is the leading cause of death in young adults, but homicides and suicides also

rank high, with a large number involving firearms.<sup>20</sup> Because firearm violence is under intense scrutiny, the debate over effective public policy requires accurate and lucid findings that synthesize large amounts of epidemiologic data.

**Table 2.** General Multiple Linear Regression Model for Carry Scale (No Issue, May Issue, Shall Issue, Unrestricted)

| X-variable  | Y-variable                   | Coefficient | SE     | p Value | Adjustment variable |
|-------------|------------------------------|-------------|--------|---------|---------------------|
| Carry scale | Log (UCR homicide)           | 0.0014      | 0.0254 | 0.96    | State, year         |
| Carry scale | Log (UCR violent crime)      | -0.0054     | 0.0070 | 0.44    | State, year         |
| Carry scale | Log (UCR rape)               | 0.0086      | 0.0118 | 0.46    | State, year         |
| Carry scale | Log (UCR robbery)            | -0.0178     | 0.0123 | 0.15    | State, year         |
| Carry scale | Log (UCR aggravated assault) | -0.0022     | 0.0074 | 0.77    | State, year         |
| Carry scale | Log (UCR burglary)           | 0.0023      | 0.0082 | 0.78    | State, year         |
| Carry scale | Log (CDC homicide)           | 0.0330      | 0.0233 | 0.16    | State, year         |
| Carry scale | Log (CDC firearm homicide)   | 0.0274      | 0.0263 | 0.30    | State, year         |

CDC, Centers for Disease Control and Prevention; UCR, Uniform Crime Reporting system.

**Table 3.** General Multiple Linear Regression Model for Carry Binary (Restricted vs Non-Restricted)

| X-variable         | Y-variable                   | Coefficient | SE     | p Value | Adjustment variable |
|--------------------|------------------------------|-------------|--------|---------|---------------------|
| Restriction binary | Log (UCR homicide)           | -0.0040     | 0.0400 | 0.92    | State, year         |
| Restriction binary | Log (UCR violent crime)      | -0.0105     | 0.0107 | 0.33    | State, year         |
| Restriction binary | Log (UCR rape)               | -0.0008     | 0.0168 | 0.96    | State, year         |
| Restriction binary | Log (robbery)                | -0.0273     | 0.0201 | 0.17    | State, year         |
| Restriction binary | Log (UCR aggravated assault) | -0.0070     | 0.0106 | 0.51    | State, year         |
| Restriction binary | Log (UCR burglary)           | 0.0028      | 0.0151 | 0.85    | State, year         |
| Restriction binary | Log (CDC homicide)           | 0.0441      | 0.0370 | 0.23    | State, year         |
| Restriction binary | Log (CDC firearm homicide)   | 0.0632      | 0.0486 | 0.19    | State, year         |

CDC, Centers for Disease Control and Prevention; UCR, Uniform Crime Reporting system.

In this study, our results demonstrate that state legislative changes have resulted in increased liberalization of the concealed-carry permits process. As these laws have increased the ability of civilians to purchase and legally carry firearms outside of the home, one logical argument could be that increased homicide and violent crime rates would follow. However, after adjusting for several population and demographic factors, we demonstrated that the rates of homicide and violent crime were not significantly increased after state laws were passed making access to concealed-carry permits less restricted. These important findings should inform further public policy research to help determine root causes and solutions to firearm-related homicide and violent crime in the future.

In the US, the ability to possess firearms is considered a fundamental individual right, albeit subject to some restrictions.<sup>6</sup> However, even some restrictions, such as mental illness, are being increasingly scrutinized by the courts<sup>21</sup> and the medical profession.<sup>22</sup> Less clear is the role of concealed-carry of firearms by civilians. Legal scholars and courts are split on the constitutional necessity of allowing civilian concealed-carry outside the home<sup>23-27</sup> and the US Supreme Court has not, as of yet, weighed in on the issue. Nevertheless, over the last 30 years, every state, as well as the District of Columbia, has adopted some form of legislation allowing some form of legal civilian concealed firearm carry. By conservative estimates, across the country, more than 6.5% of the adult population has a permit to carry a concealed firearm, and in some states, this number is as high as 20%.<sup>8</sup>

It is also clear that public interest in concealed-carry is accelerating. One recent study noted a significant growth in concealed-carry permit applications in the 5 states examined.<sup>28</sup> Another review demonstrated that during the 10-year period from 2007 to 2016, the number of concealed-carry permits across the country dramatically increased, by 256%.<sup>8</sup> It should be noted that these numbers likely significantly underestimate concealed-carry, as many states have adopted unrestricted or

constitutional carry legislation, where permits are not needed. Of those who can carry a concealed handgun, it is estimated that about 9 million Americans carry at least monthly, with 3 million carrying daily.<sup>29</sup>

Public opinion regarding concealed-carry also appears to be shifting. A recent Gallup poll indicated that 56% of the respondents believed that the US would be safer if more citizens carried concealed weapons.<sup>30</sup> In addition, an increasing percentage believe that the presence of guns make a home safer: 63% in 2014 up from 35% in 2000.<sup>31</sup> Although these general polls show an improvement in public opinion regarding firearms and concealed-carry, these opinions are not universal. Wolfson and colleagues<sup>32</sup> demonstrated a large discrepancy toward concealed-carry restrictions between gun owners and nonowners, including both the ability and locations where concealed-carry should be permitted.<sup>32</sup> It is also clear that options on gun ownership and acceptable use vary widely based on gun ownership, political affiliation, and sex.<sup>33</sup>

One major question involves the potential deterrent effect of concealed-carry. It is increasingly clear that those with concealed-carry permits do use their weapons defensively, but the exact number and characteristics of these incidents are in question. Estimates of annual defensive use of firearms vary widely, from as low as 64,615<sup>34</sup> to as high as 2.5 million.<sup>35</sup> In addition, rates of defensive gun use may vary significantly between urban and rural areas.<sup>36</sup> It is clear that defensive use of firearms often does not involve the actual discharge of a firearm, and in many cases, may go unreported to law enforcement. However, civilian defensive use of firearms can involve high profile situations. In the most recent analysis of mass shooting events, the US Department of Justice noted that in 20% of incidents, civilians engaged the shooter, and in 10% of incidents, civilians with concealed-carry permits were successful in stopping the shooting and preventing further injuries and loss of life.<sup>37</sup>

Despite this, debate regarding the role of a civilian with a concealed-carry permit continues. Estimates range from



a major deterrent effect,<sup>2,8</sup> to an effect only when allowing some form of concealed-carry in no issue states,<sup>38</sup> to no deterrent effect whatsoever.<sup>39</sup> One study found no effect for concealed-carry on deterrence of mass shootings.<sup>40</sup> Another suggested that concealed-carry may be a method to decrease the incidence of sexual violence against women.<sup>41</sup> The Eastern Association for the Surgery of Trauma, in a review of concealed-carry laws and firearm violence prevention, could not make a recommendation regarding concealed-carry legislation due to the lack of data.<sup>42</sup> Overall, this issue remains unresolved, but it is clear that many Americans feel that gun ownership enhances their safety.<sup>31</sup>

Another area of controversy involves the potential for crimes committed by those who are legally carrying firearms. One organization, the Violence Policy Center, maintains a watch list of “concealed-carry killers,” which reports on crimes in which individuals with concealed-carry permits have been accused or convicted. As of June 2017, they reported more than 1,000 non-self-defense deaths involving individuals who had obtained concealed-carry permits. However, serious concerns have been raised regarding the methodology and accuracy of the Violence Policy Center data.<sup>43</sup>

In fact, several studies have shown that the rate of crime committed by those with concealed-carry permits is actually low compared with the general population, but it does demonstrate a trend toward some specific offenses.<sup>10</sup> Another study of concealed-carry holders in Texas and Florida demonstrated that the civilians with concealed-carry permits have an arrest and conviction rate one-sixth that of police officers.<sup>8</sup> Looking specifically at firearms violations, concealed-carry permit holders have been shown to commit these at a rate less than one-seventh that of police officers.

Given the inconsistent results of previous studies examining the potential effects of concealed-carry on crime, questions have been raised as to what the true effect is. Although some demonstrate decreased violent crime,<sup>8,44-46</sup> others have shown increases including firearm- and handgun-related homicides,<sup>3,4</sup> and still others demonstrate mixed results.<sup>47,48</sup> How can data demonstrating low rates of crime among concealed-carry permit holders be reconciled with studies that suggest higher crime rates with concealed-carry? One study looking at this phenomenon questions the potential cause and effect and suggests that the increased interest and prevalence of concealed-carry may be a result of increased crime, rather than a cause.<sup>49</sup> Khalil and colleagues<sup>50</sup> found that the source of firearms may be a major issue, with a strong association between illegally obtained firearms and subsequent homicides and aggravated assaults.

In terms of statistical methods, many inconsistencies found in previous studies may be the result of the statistical modeling used in the analysis of the data. In this study, a rigorous statistical model was used to potentially eliminate significant errors in estimating the effect and its precision. The dataset consisted of 1 observation per state and District of Columbia per year during the study period. The dataset was complete and there were no missing observations. For each observation, the variables to be predicted (after log transformation) were the UCR homicide rate, UCR violent crime rate, UCR rape rate, UCR burglary rate, UCR aggravated assault rate, CDC homicide rate and the CDC firearm homicide rate. Legislative status (as an ordered scale with 4 levels and as a binary level) was the predictor variable of interest, and poverty rate and unemployment rate were adjustment variables. The primary “adjustment variables” were the effects of year and state considered as unique additive “main effects.” By considering these main effects in the model, the analysis, in essence, considers the deviations of each state’s pattern of event rates from the overall pattern of event rates across states, and it also removes the overall state-to-state variation in mean rates.

In summary, we removed both the state-to-state variation in mean rates, and the global average year-to-year variation in these rates. In effect, the “residuals” derived were then analyzed for any association between legislative status and the residual log rate, adjusting for poverty level and unemployment rate. General linear regression with a repeated measures option that included an autoregressive correlation structure was used. Such a correlation structure allows for the fact that state-specific yearly event rates that are close in time (or the log-residual rates) are likely to be autocorrelated, meaning that they do not provide independent observations on the association between legislative status and event rates. The legislative status history is also highly autocorrelated because adjacent years are much more likely to share the same legislative status than widely separated years. An analysis that does not take into account this autocorrelation structure would be prone to overestimating the precision of the parameter estimates, by underestimating the standard errors.

When we performed the analyses without making this adjustment, but assuming independence, the “correct” analyses resulted in standard errors that were approximately twice those of the naïve analyses. This analysis was repeated using additional adjustment variables for poverty and unemployment; however, these did not significantly change the results. It is important to note that many of the variables, while not significant, did have effects that pointed in a similar direction. If a naïve statistical approach had been used, significance would likely have

been demonstrated. For example, if the naïve and inaccurate assumption is made that all yearly observations within a state are independent of each other, then the association between the carry status and the CDC homicide rate is highly significant ( $3.5\% \pm 1.1\%$  per level of liberalizing,  $p = 0.0011$ ). This inaccurate assumption would lead to an inaccurate assessment of the level of evidence.

Our study has several limitations. Foremost, we do not account for the number of people who actually obtain a permit and frequently carry a firearm, only for the availability of a mechanism to obtain a concealed-carry permit. Data on number of permit holders is not universally available, and in an increasing number of states, no permit is necessary to carry a concealed firearm. Furthermore, considering legislative changes to have occurred in the year legislation was enacted may potentially lead to underestimation of the effect in the first year, especially if the legislation was enacted near the end of the calendar year. It is also possible that some lag in the effect of new legislative change exists; however, the legislative change occurred over a broad time frame, which may likely minimize this potential effect. In addition, we did not account for the effect of open carry, where a person can legally carry a firearm as long as it is exposed and not concealed. This practice is legal in most states, subject to some limitations, but remains relatively uncommon. We also did not consider the overall effect of increasing firearm ownership because this will be a topic of future research. Another limitation comes directly from the crime and injury data itself. Many local and national events can influence crime rates, and it is exceedingly difficult, if not impossible, to adjust for every covariate using national public data. The statistical methods attempted to minimize these effects. Concerning violent crime, the results cannot account for unreported crime or defensive use of firearms. This may underestimate the crime prevention potential of increased concealed-carry on homicide and other violent crime. Finally, given the nature of our study, we do not attempt to assign causation, only association.

## CONCLUSIONS

This study demonstrates no statistical association between the liberalization of state level firearm carry legislation over 3 decades and the rates of homicides, firearm homicides, or other violent crime, using a rigorous statistical model. Given the inconsistencies in previous work, this study underscores the need for further research that evaluates the causes of firearms violence. However, as stated in a recent publication from the Institute of Medicine and National Research Council, “The evidence generated by implementing a public health research agenda can enable

the development of sound policies that support both the rights and the responsibilities central to gun ownership in the US. In the absence of this research, policy makers will be left to debate controversial policies without scientifically sound evidence about their potential effects.”<sup>51</sup> Based on our data, policy efforts aimed at injury prevention and the reduction of firearm-related violence should likely investigate other targets for potential intervention. However, in the end, it is clear that further high-quality research is needed to help our society make rational decisions to help minimize violence and loss of life.

## Author Contributions

Study conception and design: Hamill, Hernandez, Bailey, Schiller

Acquisition of data: Hamill

Analysis and interpretation of data: Hamill, Hernandez, Bailey, Zielinski, Matos, Schiller

Drafting of manuscript: Hamill, Hernandez, Bailey

Critical revision: Hamill, Hernandez, Bailey, Zielinski, Matos, Schiller

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