Journal of Trauma and Acute Care Surgery, Publish Ahead of Print
DOI: 10.1097/TA.0000000000002060

Changes in US Mass Shooting Deaths Associated With the 1994-2004 Federal Assault Weapon Ban: Analysis of Open-Source Data

Charles DiMaggio PhD, MPH, Jacob Avraham MD, Cherisse Berry MD, Marko Bukur MD, Justin Feldman ScD, Michael Klein MD, Noor Shah MD, Manish Tandon MD, Spiros Frangos, MD, MPH

Author Affiliations: All authors are affiliated with the New York University School of Medicine, Department of Surgery, Division of Trauma and Critical Care Surgery

77th Annual Meeting of AAST and 4th World Trauma Congress

Sep 26 - 29, 2018

San Diego, California

Corresponding Author:

Charles DiMaggio, PhD, MPH

Professor of Surgery and Population Health

Director of Injury Research

Department of Surgery

New York University School of Medicine

462 First Avenue, NBV 15

New York, NY 10016-9196

Charles.DiMaggio@nyumc.org

Office: 212.263.3202

Mobile: 516.308.6426

Email Addresses:

Charles.DiMaggio@nyumc.org

Jacob.Avraham@med.nyu.edu

Cherisse.Berry@nyumc.org

Marko.Bukur@nyumc.org

Justin.Feldman@nyumc.org

Michael.Klein@nyumc.org

Noor.Shah@med.nyu.edu

Manish.Tandon@nyumc.org

Spiros.Frangos@nyumc.org

Funding Statement: There are no federal or non-federal funding sources associated with this study.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Background A federal assault weapons ban has been proposed as a way to reduce mass shootings in the U.S. (U.S). The Federal Assault Weapons Ban (A.W.B.) of 1994 made the manufacture and civilian use of a defined set of automatic and semi-automatic weapons and large capacity magazines illegal. The ban expired in 2004. The period from 1994 to 2004 serves as a single-arm pre-post observational study to assess the effectiveness of this policy intervention. **Methods** Mass shooting data for 1981 to 2017 were obtained from three well-documented, referenced, and open-source sets of data, based on media reports. We calculated the yearly rates of mass shooting fatalities as a proportion of total firearm homicide deaths and per U.S. population. We compared the 1994-2004 federal ban period to non-ban periods, using simple linear regression models for rates and a Poison model for counts with a year variable to control for trend. The relative effects of the ban period were estimated with odds ratios. **Results** Assault rifles accounted for 430 or 85.8% of the total 501 mass-shooting fatalities reported (95% CI 82.8, 88.9) in 44 mass-shooting incidents. Mass shootings in the U.S. accounted for an increasing proportion of all firearm-related homicides (coefficient for year = 0.7, p = 0.0003), with increment in year alone capturing over a third of the overall variance in the data (Adjusted R-squared = 0.3). In a linear regression model controlling for yearly trend, the federal ban period was associated with a statistically significant 9 fewer mass shooting related deaths per 10,000 firearm homicides (p = 0.03). Mass-shooting fatalities were 70% less likely to occur during the federal ban period (Relative Rate = 0.30, 95% CI 0.22,0.39). **Conclusions** Mass-shooting related homicides in the U.S. were reduced during the years of the federal assault weapons ban of 1994 to 2004.

Study Type: Observational

Level of Evidence: III/IV

Keywords: Firearms, Mass-Shootings, Assault Weapons, Epidemiology

Background

Increases in firearm-related injuries, particularly mass-shooting related fatalities, in the United States (US) have contributed to a polarizing and sometimes contentious debate over gun-ownership and limiting weapons characterized as assault weapons.[1 2] Despite the increasing sense that there is an epidemic of indiscriminate firearm violence in our schools and public spaces, there is a paucity of public health evidence on the topic. Among a number of recommendations, a federal Assault Weapons Ban (A.W.B.) has been proposed as a way to prevent and control mass shootings in the U.S. In this paper we assess evidence for the effectiveness of such a ban in preventing or controlling mass-shooting homicides in the U.S.

While mass shootings occur in other industrialized nations, the U.S. is particularly prone to these crimes. In a recent 30-year period, the U.S. had double the number of mass-shooting incidents than the next 24 industrialized nations combined.[3] Any public perception of recent increases in the number of these events is borne out by analysis of available data.[4] By one measure, there have been more deaths due to mass shootings in the U.S. in the past 18 years than in the entire 20th century.[5] While there is some debate about the role of mental illness in mass shootings,[6 7 8], many high-profile recent mass shootings (Aurora, Colo.; Roseburg, Ore.; San Bernadino, Calif.; Newtown, Conn.; Orlando; Las Vegas; Sutherland Springs, Texas) have been characterized by the use of semi-automatic assault rifles, [9] leading some to advocate for restrictions on the manufacture and sale of these weapons.

While survey results indicate that researchers in criminology, law and public health rank an assault weapons ban as one of the most effective measures to prevent mass-shootings, and that 67% of the US general population support such a ban,[10] the existing evidence on banning assault weapons is scant and sometimes contradictory. Most evidence is related to the Federal A.W.B.

of 1994, which made illegal the manufacture and use by civilians of a defined set of automatic and semi-automatic weapons and large capacity magazines. Formally known as "The Public Safety and Recreational Firearms Use Protection Act", was part of the broader "Violent Crime Control and Law Enforcement Act of 1994", the ban lasted 10-years, expiring in 2004 when the U.S. Congress declined to renew it.

In a study soon following the implementation of the 1994 ban, researchers reported a 55% decrease in the recovery of assault weapons by the Baltimore City Police in the first six months of 1995, indicating a statistically significant 29 fewer such firearms in the population.[11] In a 2009 study based on ICD9 external cause of injury codes for patients younger than 18 in the U.S., 11 states with assault and large-capacity magazine bans, as well as other firearm laws, were compared to 33 states without such restrictions. The incidence of firearm injuries per 1,000 total traumatic injuries was significantly lower in states with restrictive laws, 2.2 compared to 5.9.[12] In contrast, a comprehensive 2001 evaluation of the FWA itself concluded there was "no evidence of reductions in multiple-victim gun homicides or multiple-gunshot wound victimizations". The authors cautioned their results should be "interpreted cautiously" because of the short time period since the ban's inception, and that future assessments were warranted.[13] More recent studies, while not primarily addressing the U.S. federal A.W.B. have found results generally consistent with its effectiveness in preventing mass-shooting fatalities. [14] [15]

We believe sufficient time has passed and enough data have accumulated to treat the period from 1994 to 2004 as a naturalistic pre-post observational comparison period for the association of the A.W.B. with changes in mass-shootings in the US. Because there is no authoritative source or registry, or even a widely-agreed upon definition for these incidents, we obtained data from three open source references and restricted our analyses to only those incidents confirmed by all three sources. We assess evidence for the potential effectiveness of such a ban in preventing and controlling mass-shooting homicides in the U.S. We hypothesized that the implementation of the Federal A.W.B. contributed to a reduction in mass shooting deaths as measured by the number and rate of mass shooting fatalities before, during and after the federal A.W.B.

Methods

Mass incident shooting data were obtained from three independent, well-documented and referenced online sources: Mother Jones Magazine, the Los Angeles Times and Stanford University.[16] [17] [18] These sources have each been the basis for a number of previous studies.[19] [20] [21] [22] [23] [24] [25] [26] Data from the three online open-source references were combined. Analyses were restricted to incidents reported by all three sources. Entries were further restricted to those for which four or more fatalities (not including the shooter) were reported, which meets the strictest definition of mass shootings as defined by the Federal Bureau of Investigation.[27] [28] Yearly homicide data were obtained from the US Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System (WISQARS) an online database of fatal and nonfatal injury.[29] Because 2017 data were not yet available in the WISQARS system, data for firearm-related homicide data for that year were obtained from a separate online source.[30]

A variable was created to indicate the 1994 to 2004 period as the federal ban period. We attempted to identify incidents involving assault weapons. An assault weapon has been defined as semiautomatic rifle that incorporates military-style features such as pistol grips, folding stocks, and high-capacity detachable magazines.[31] In this study, assault weapons were identified using the text search terms ”AK”, ”AR”, ”MCX”, ”assault”, ”Assault”, or ”semiautomatic” in a text field for weapon details. These terms were based on descriptions of the federal assault ban legislative language.[32] The total number of mass shooting fatalities and injuries were aggregated by year and merged with the yearly firearm homicide data.

The rate of mass shooting fatalities per 10,000 firearm homicide deaths was calculated. For the years covered by the data sources, we calculated (1) the total and yearly number of mass-shooting incidents that met the strictest criteria and were confirmed by all three sources, (2) the number of all-weapon (assault and non-assault weapons) mass-shooting fatalities, and (3) the case-fatality ratio of all-weapon mass-shooting fatalities per 100 total mass-shooting fatalities and injuries were reported. The yearly case-fatality ratio was plotted with overlying Loess line for trend and standard error limits. We also plotted the yearly rate of mass shooting fatalities per 10,000 firearm-related homicides with an overlying simple linear model with year as the predictor for (1) the total time period, and (2) for pre-ban, ban and post-ban time periods.

We evaluated assumptions of normality and linearity of the data using graphical methods such as density plots and Q-Q normal plots as well as summary statistics. We tested the hypothesis that the federal ban period was associated with a decrease in the number and rate of mass-shooting fatalities in the U.S. with a multiple linear regression model, with total homicide-based mass-shooting fatality rate as the outcome variable, a dichotomous indicator variable for the federal ban period as the predictor variable, and year as a control variable for trend over time. We calculated the relative risk of mass shooting fatalities during the federal ban period compared to non-ban periods by using the "epitab" function of the R "epitools" package. This estimate is based on the ratio of the fatality rate during the ban period divided by the fatality rate during the non-ban period. All results are presented with two-sided p-values with a significance level of 0.05 and/or 95% confidence intervals. We conducted subgroup analysis with data restricted to incidents in which an assault-type weapon was explicitly noted.

We conducted analyses to test the sensitivity of our results to the choice of denominator with linear regression models controlling for trend with yearly rates based on (1) CDC WISQARS homicide data ending in 2016, (2) extrapolated CDC WISQARS homicide data for 2017, and (3) population denominator-based rates. We tested the robustness of our underlying modeling assumptions with an alternate mixed-effects generalized linear model of yearly mass shooting fatality counts with an observation-level random effect to account for overdispersion.

The study was determined to be exempt as non-identifiable data. The study data and analytic code are available for download at http://www.injuryepi.org/styled-2/.

Results

The three data sources listed incidents ranging in number from 51 (LA Times) to 335 (Stanford) and in dates from 1966 (Stanford) to 2018 (LA Times). There were a total of 51 reported cases of mass shootings between 1981 and 2017 confirmed by all three sources. Forty-four of these incidents met the strictest criteria for mass shootings (4 or more killed), totaling 501 all-weapon fatalities. In total 1,460 person were injured or killed over the 37-year period, for a total case-fatality ratio of 34.3% (95% CI 31.9, 36.8). The overall rate of mass shooting fatalities per 10,000 firearm-related homicides was 10.2 (95% CI 9.4, 11.2). There was an overall increase in the all-weapon yearly number of mass-shooting fatalities in the U.S. during the study period, (Figure 1) and evidence of a decrease in case fatality in the post 2010 period. (Figure 2) Incidents in which weapons were characterized as assault rifles accounted for 430 or 85.8% of mass-shooting fatalities (95% CI 82.8, 88.9). Weapons characterized as assault rifles accounted for *all* mass-shooting fatalities in 15 out of the 24 (62.5% [95% CI 42.6, 78.9]) years for which a mass-shooting incident was reported, accounting for a total of 230 fatalities.

Between 1981 and 2017 mass shootings in the U.S. accounted for an increasing proportion of all firearm-related homicides, with increment in year accounting for nearly 32% of the overall variance in the data. During the years in which the A.W.B. was in effect, this slope decreased, with an increase in the slope of yearly mass-shooting homicides in the post-ban period. (Figure 3) A similar pattern was evident in data restricted to those incidents characterized as involving assault weapons. (Figure 4)

In a linear regression model controlling for yearly trend, the federal ban period was associated with a statistically significant 9 fewer mass-shooting related deaths per 10,000 firearm homicides per year. (Table 1) The model indicated that year and federal ban period alone accounted for nearly 40% of all the variation in the data (Adjusted R-squared = 0.37). A sub-analysis restricted to just those incidents characterized by the use of an assault weapon indicated that 7 preventable deaths during the ban period were due to assault weapons alone. (Table 2)

The risk of mass shooting fatalities during the federal van period was 53 /140,515 total firearm homicides compared to 448 / 348,528 during the non-ban periods, for a risk ratio of 0.30 (95% CI 0.22, 0.39). The calculated risk ratio for the association of the federal ban period with mass-shooting fatalities as a proportion of all firearm-related homicides was 0.29 (95% CI 0.22,0.29), indicating that mass-shooting fatalities were 70% less likely to occur during the federal ban period.

The results of our sensitivity analyses were consistent with our main analyses for total mass shooting fatalities. In a linear regression analysis controlling for yearly trend and restricted to the period ending in 2016 using just CDC WISQARS homicide data as the denominator, the effect of ban period was associated with a statistically significant 8 fewer mass shooting related deaths per 10,000 firearm homicides per year. (Coefficient for ban period = 8.0, p=0.05) In a similar model using extrapolated CDC WISQARS homicide data for 2017 instead of Online Gun Violence Archive data as the denominator, the effect of ban period was associated with a statistically significant 9 fewer mass shooting related deaths per 10,000 firearm homicides per year. (Coefficient for ban period = 8.6, p=0.03) A model based on the total yearly US population as the denominator, the effect of ban period was associated with a statistically significant 0.4 fewer mass shooting related deaths per 10,000,000 population. (Coefficient for ban period = 0.4, p=0.02)

The results of a mixed-effects generalized linear Poisson model of yearly mass shooting fatality counts with an observation-level random effect to account for overdispersion were very similar whether the offset variable was the number of total firearm deaths or the population size. In either case, the assault-weapons ban period was associated with an approximately 85% reduction in mass shooting fatalities. (Table 3)

Discussion

Recently 75% of members of the ACS Committee on Trauma endorsed restrictions to “"civilian access to assault rifles (magazine fed,semi-automatic, i.e., AR-15)", [33] and 76% of the Board of Governors were in favor of a limit to "… civilian access to ammunition designed for military or law enforcement use (that is, armor piercing, large magazine capacity)"[34] In 2015, the American College of Surgeons (ACS) joined seven of the largest most prestigious professional health organizations in the U.S. and the American Bar Association to call for ”restricting the manufacture and sale of military-style assault weapons and large-capacity magazines for civilian use”[35]. This analysis adds evidence to support these recommendations.

No observational epidemiologic study can answer the question whether the 1994 US federal assault ban was causally related to preventing mass-shooting homicides. But, this study adds to the evidence by narrowly focusing our question on the potential effect of a national assault weapon ban on mass shootings as measured through the lens of case fatality. While the data are amenable to a number of additional analyses, such as stratification by location (e.g. school vs. non-school) or by characterization of large-capacity magazines vs. non, we chose to focus only on year of occurrence and total number of fatalities. In this way, we relied on the least subjective aspects of the published reports. We believe our results support the conclusion that the ban period was associated with fewer overall mass-shooting homicides. These results are also consistent with a similar study of the effect of a 1996 ban on assault type weapons in Australia after which mass-shooting fatalities dropped to zero. [36]

While the absolute effects of our regression analyses appears modest (7 to 9 fewer deaths per 10,000 firearm-homicides), it must be interpreted in the context of the overall number of such fatalities, which ranges from none to 60 in any given year in our data. But, if our linear regression estimate of 9 fewer mass-shooting related deaths per 10,000 homicides is correct, an assault weapons ban would have prevented 314 of the 448 or 70% of the mass-shooting deaths during the non-ban periods under study. Notably, this estimate is roughly consistent with our odds ratio estimate and Poisson model results.

Our results add to the documentation that mass-shooting related homicides are indeed increasing, most rapidly in the post-ban period, and that these incidents are frequently associated with weapons characterized as assault rifles by the language of the 1994 AWB. We did not find an increase in the case fatality ratio of mass-shooting deaths to mass-shooting injuries. This might at first seem counterintuitive and paradoxical. The destructive effect of these weapons is unequivocal. They are engineered to cause maximum tissue damage rapidly to the greatest number of targets. But it may be that the use of these kinds of weapons results in indiscriminate injury with additional rounds more likely to injure more people increasing the denominator in a case-fatality ratio. By contrast, the use of non-assault weapons may result in more precise targeting of victims. It is also possible that improvements in trauma care are driving down case fatality.[37] And it is worth noting that in absolute terms there were many more fatalities outside the ban period, and that survivable injury comes with its own physical, emotional, and economic costs, which have been estimated at $32,237 per hospital admission.[38]

Despite US federal funding restrictions on firearm related research dating to 1996,[39] [40] there is a small but growing number of analyses of mass-shooting violence in the U.S. Many papers have focused on the mental health aspects of these incidents,[41] [42] [43] or on social effects like increased firearm acquisition following mass shootings. [44] [45] But, fewer studies have taken a strictly public health or clinical approach. Among these an autopsy-based study of the incidence and severity of mass-shooting casualties concluded the wound patterns differed sufficiently from combat injuries to require new management strategies, indicating there is much to be learned from a systematic epidemiological perspective. [46] Recently, there have been calls to remove such funding restrictions from both academics and elected officials from across the political spectrum. [47] [48]

Our choice of data and analytic approach may reasonably be debated. We chose to base our analyses on the yearly rate of mass-shooting fatalities per 10,000 overall firearm homicides. This is not a population-based risk estimate, but is in fact a risk as commonly used in the epidemiologic literature which is essentially a probability statement, i.e. the number of events that occurred over the number of times that event could occur. It is the risk of a homicide occurring as a result of a mass shooting. It may be considered a strong assumption to build mass shooting death rates based on the overall firearm homicide rate. The demographics of most homicide victims may differ appreciably from those of mass-shooting victims. We selected this approach from among a number of imperfect potential denominators, believing that basing the rates on the number of firearm-homicides partly controls for secular trends in overall homicides and firearm availability. Our sensitivity analyses indicate that our results were robust to most any choice of denominator. We chose linear regression as our primary model because it was straightforward, accessible to most readers, accounted for linear trends in the data, and returned results in the metric in which we were most interested, i.e. changes in the rate of fatalities. Our comparative Poisson model results were essentially consistent with the primary model.

These analyses are subject to a number of additional limitations and caveats, primary among which, is that there is no authoritative source of data on mass shooting, and any one source may be biased and incomplete. It was for this reason that we chose to combine three independent sources of data, each with its own strengths and weaknesses, and base our analyses only on those numbers that were verified by all three sources. We further restricted our analyses to only the number of fatalities and the year in which the incident occurred, and to the strictest definition of mass shootings as defined by the Federal Bureau of Investigation.[49] [50] Even with this approach, the data remain imprecise and subject to differing definitions. We attempted to compensate for this by framing our questions as precisely as possible, following the advice of the scientist and statistician John Tukey to pursue, ”… an approximate answer to the right question ... than the exact answer to the wrong question...”

In this study, we failed to falsify the hypothesis that the AWB was associated with a decrease in mass shooting fatalities in the U.S. But, it is important to note that our model did not include important and potentially confounding factors like state-level and local differences in assault-weapon laws following the sun downing of the federal AWB. Additional analyses including such variables and using approaches like propensity score matching and regression discontinuity[51] with data further aggregated to state and local levels are necessary to test the strength and consistency of our results.

Federally referenced denominator data were not available for the last year of the study. We chose to use data from the Online Gun Violence Archive to account for firearm homicide in 2017. This resource is a non-partisan not-for-profit group founded and maintained by a retired computer systems analyst and gun advocate.[52] The alternative would have been to extrapolate from the CDC data, but the 15,593 firearm-related homicides reported by the Online Gun Violence Archive in 2017 was more consistent with the 14,415 reported by CDC in 2016 compared to the 11,599 predicted by an extrapolation, and returned more conservative estimates of the increased rate of recent mass shootings. We note there were many years in which the number of mass-shooting fatalities is listed as zero. There were, in fact, fatalities and incidents in those years that could meet a definition of mass shooting, but they were not reported by all three sources, or did not meet the strict criteria we set for this analysis.

An assault weapon ban is not a panacea, nor do our analyses indicate that an assault weapon ban will result in fewer overall firearm-related homicides. It is important to recognize that suicides make up the majority of firearm related deaths in the U.S., accounting for 60.7% of 36,252 deaths from firearms in 2015.[53] But, while this is a critically important issue in its own right, suicides differ fundamentally from mass-shootings, and are unlikely to be affected by an assault weapons ban. And, compared to the 501 mass-shooting fatalities we counted, there were 489,043 firearm-related homicides in the U.S. Public health efforts should be directed at reducing all gun violence and must be multi-pronged, including targeted initiatives to address mental illness and reducing access to weapons in those with a propensity for violence. But taken in the context of the increase in mass shootings in the U.S. , these results support the conclusion that the federal A.W.B. of 1994 to 2004 was effective in reducing mass-shooting related homicides in the U.S., and we believe our results support a re-institution of the 1994 federal assault weapons ban as a way to prevent and control mass shooting fatalities in the United States.

References

[1] Wolchover N. "Why Gun Control Is So Contentious in the US" *LiveScience*. 20 July 2012 https://www.livescience.com/21741-gun-control-second-amendment.html Accessed 10 August 2018.

[2] Bond S. "Students take the lead in US gun control debate". *Financial Times*. 23 February 2018. https://www.ft.com/content/9341021e-1818-11e8-9376-4a6390addb44 Accessed 10 August 2018.

[3] Lemieux F. "6 Things to Know about Mass Shootings in America" *Scientific American*. 13 June 2016. https://www.scientificamerican.com/article/6-things-to-know-about-mass-shootings-in-america/. Accessed 6 June 2018.

[4] Webster DW. The True Effect of Mass Shootings on Americans. *Annals of Internal Medicine*. 16 May 2017. The http://annals.org/aim/fullarticle/2624992/true-effect-mass-shootings-americans. Accessed 6 June 2018.

[5] Katsiyannis A, Whitford DK, Ennis RB. Historical Examination of United States Intentional Mass School Shootings in the 20th and 21st Centuries: Implications for Students, Schools, and Society. *Child Fam Stud* .(19 April 2018). https://doi.org/10.1007/s10826-018-1096-2

[6] Follman, M. "Mass Shootings: Maybe What We Need Is a Better Mental-Health Policy" *Mother Jones* 9 November 2012. https://www.motherjones.com/politics/2012/11/jared-loughner-mass-shootings-mental-illness/ Accessed 11 August 2018

[7] Carey, B. "Are Mass Murderers Insane? Usually Not, Researchers Say" *New York Times*. 8 November 2017. https://www.nytimes.com/2017/11/08/health/mass-murderers-mental-illness.html Accessed 11 August 2018.

[8] Duwe G and Rocque M. "Actually, there is a clear link between mass shootings and mental illness" *Los Angeles Times*. 23 February 2018. http://www.latimes.com/opinion/op-ed/la-oe-duwe-rocque-mass-shootings-mental-illness-20180223-story.html Accessed 11 August 2018.

[9] Gillin J, Greenberg J, Jacobson L, and Valverde M.. "The facts on mass shootings in the United States" *Politifact*. 8 November 2017. http://www.politifact.com/truth-o-meter/article/2017/nov/08/facts-mass-shootings-united-states/ Access 6 June 2018.

[10] Sanger-Katz M and Bui Q. "How to Reduce Mass Shooting Deaths? Experts Rank Gun Laws" *New York Times*. 5 October 2017. https://www.nytimes.com/interactive/2017/10/05/upshot/how-to-reduce-mass-shooting-deaths-experts-say-these-gun-laws-could-help.html. Accessed 6 June 2018.

[11] D. S. Weil and R. C. Knox. The Maryland ban on the sale of assault pistols and high-capacity magazines: estimating the impact in Baltimore. *Am J Public Health*. 87(2):297–8, Feb 1997.

[12] Arash Safavi, Peter Rhee, Viraj Pandit, Narong Kulvatunyou, Andrew Tang, Hassan Aziz, Donald Green, Terence O'Keeffe, Gary Vercruysse, Randall S Friese, et al. Children are safer in states with strict firearm laws: a national inpatient sample study. *J Trauma Acute Care Surg*, 76(1):146–50; discussion 150–1, Jan 2014.

[13] Koper CS, and Roth JA. The Impact of the 1994 Federal Assault Weapon Ban on Gun Violence Outcomes: An Assessment of Multiple Outcome Measures and Some Lessons for Policy Evaluation. *J Quant Criminol*, Vol. 17, No. 1, 2001

[14] Gius M. The impact of state and federal assault weapons bans on public mass shootings, *Applied Economics Letters*. 2015, 22(4), 281-284.

[15] Lemieux F, Bricknell S, and Prenzler, T.. Mass shootings in Australia and the United States, 1981-2013". *Journal of Criminological Research, Policy and Practice* 1(3): 131-142.

[16] Follman M, Aronsen G, Pan D and Caldwell M. US Mass Shootings, 1982-2018: Data from Mother Jones' Investigation. *Mother Jones*, 2012. https://www.motherjones.com/politics/2012/12/mass-shootings-mother-jones-full-data/ Accessed 3 June 2018.

[17] The Los Angeles Times Staff. "Deadliest U.S. Mass Shootings, 1984-2017." *Los Angeles Times*, Oct 1, 2017, timelines.latimes.com/deadliest-shooting-rampages/ Accessed 29 August 2018

[18] Stanford Mass Shootings in America, courtesy of the Stanford Geospatial Center and Stanford Libraries, 2016. Available at: https://library.stanford.edu/projects/mass-shootings-america. Accessed 29 August 2018

[19] Fox JA, Levin J, and Fridel EE. Extreme killing: Understanding serial and mass murder. Sage Publications, 2018.

[20] Dillon L. Mass Shootings in the U.S.: An Exploratory Study of the Trends from 1982-2012. PhD thesis, 2014.

[21] Lankford A. Public mass shooters and firearms: a cross-national study of 171 countries. *Violence Vict*, 31(2):187, 2016.

[22] Lowe SR, and Galea S. The mental health consequences of mass shootings. *Trauma Violence Abuse*, 18(1):62–82, 2017.

[23] Fox JA, Fridel EE. The tenuous connections involving mass shootings, mental illness, and gun laws. *Violence Gend*. 2016 Mar 1;3(1):14-9.

[24] Luca M, Malhotra DK, Poliquin C. The Impact of Mass Shootings on Gun Policy. Harvard Business School NOM Unit Working Paper No. 16-126. 1 Oct. 2016.

[25] Buchholtz LK. Command-Directed Mental Health Evaluations and Mental Health Related Discharges from the U.S. Military: An Argument for Command Authority. *J Health Care Finance*. 2016 Sep 21.

[26] Bradley K. Code Blue: The Expanding Field of Tactical/Battlefield Medicine. *J Law Enforcement*. 2017 Apr 1;6(2).

[27] Smart, R. Mass Shootings: Definitions and Trends. RAND Corporation. https://www.rand.org/research/gun-policy/analysis/supplementary/mass-shootings.html Accessed 2 June 2018.

[28] Krouse, WJ, and Richardson DJ, Mass Murder with Firearms: Incidents and Victims, 1999–2013, Washington, D.C.: Congressional Research Service, R44126, 2015.

[29] Centers for Disease Control and Prevention. CDC's WISQARS (Web-based Injury Statistics Query and eporting Aystem). https://www.cdc.gov/injury/wisqars/fatal.html. Accessed 12 February 2018.

[30] The Online Gun Violence Archive: Past summary ledgers. http://www.gunviolencearchive.org/past-tolls Accessed 12 February 2018.

[31] Studdert DM, Donohue JJ, and Mello MM. Testing the Immunity of the Firearm Industry to Tort Litigation. *JAMA Intern Med*. 2017; 177(1): 102-105

[32] Public Safety and Recreational Firearms Act. P.L. 103-322, Title XI. 103rd Cong. (1994).

[33] Kuhls DA, Campbell BT, Burke PA, Allee L, Hink A, Letton RW, Masiakos PT, Coburn M, Alvi M, Lerer TJ, et al. "Survey of American College of Surgeons Committee on trauma members on firearm injury: Consensus and opportunities". *J Trauma Acute Care Surg*. 2017; 82(5): 877-886.

[34] Puls M, Kuhls D, Campbell B, Burke P, Michelassi F, and Stewart R. Survey of the American College of Surgeons Board of Governors on firearm injury prevention: Consensus and opportunities. *Bulletin of the American College of Surgeons*. 4 October 2017. 102(10):30-36.

[35] Weinberger SE, Hoyt DB, Lawrence HC, Levin S, Henley DE, Alden ER, Wilkerson D, Benjamin GC, and Hubbard WC. Firearm-related injury and death in the U.S.: a call to action from 8 health professional organizations and the american bar association. *Ann Intern Med*. 162(7):513–6, Apr 2015.

[36] Chapman S, Alpers P, and Jones, M. Association Between Gun Law Reforms and Intentional Firearm Deaths in Australia, 1979-2013. *JAMA*. 2016;316(3):291-299.

[37] DiMaggio C, Ayoung-Chee P, Shinseki M, Wilson C, Marshall G, Lee DC, c, Wall S, Maulana S, Pachter HL, Frangos S. Traumatic injury in the U.S.: In-patient epidemiology 2000–2011. *Injury*. 2016 Jul;47(7):1393-403. PMID: 27157986

[38] Peek-Asa C, Butcher B, and Cavanaugh JE. Cost of hospitalization for firearm injuries by firearm type, intent, and payer in the U.S.. *Inj Epidemiol*. 4(1):20, Dec 2017.

[39] Wexler L. "Gun Shy: How a lack of funds translates to inadequate research on gun violence in America.". *Hopkins Bloomberg Public Health Fall* 2017. https://magazine.jhsph.edu/2017/fall/features/cassandra-crifasi-hopkins-moderate-gun-owner-gun-policy-researcher/how-the-dickey-amendment-affects-gun-violence-research.html. Access 5 June 2018.

[40] Greenberg J. "Spending bill's gun research line: Does it nullify Dickey amendment?" *Politifact*. 27 March 2018. http://www.politifact.com/truth-o-meter/article/2018/mar/27/spending-bills-gun-research-line-does-it-matter/. Accessed 6 June 2018.

[41] Pinals DA, Anacker L. Mental Illness and Firearms: Legal Context and Clinical Approaches. *Psychiatr Clin North Am*. 2016 Dec;39(4):611-621.

[42] Leiner M, De la Vega I, Johansson B.. Deadly Mass Shootings, Mental Health, and Policies and Regulations: What We Are Obligated to Do. *Front Pediatr*. 2018 Apr 16;6:99.

[43] Swartz MS, Bhattacharya S, Robertson AG, Swanson JW.. Involuntary Outpatient Commitment and the Elusive Pursuit of Violence Prevention. *Can J Psychiatry*. 2017 Feb;62(2):102-108.

[44] Studdert DM, Zhang Y, Rodden JA, Hyndman RJ, Wintemute GJ. Handgun Acquisitions in California After Two Mass Shootings. *Ann Intern Med*. 2017 May 16;166(10):698-706

[45] Stroebe W, Leander NP, Kruglanski AW.. The impact of the Orlando mass shooting on fear of victimization and gun-purchasing intentions: Not what one might expect. *PLoS One*. 2017 Aug 11;12(8):e0182408.

[46] Smith ER, Shapiro G, Sarani B.. The profile of wounding in civilian public mass shooting fatalities. *J Trauma Acute Care Surg*. 2016 Jul;81(1):86-92.

[47] Behrman P, Redding CA, Raja S, Newton T, Beharie N, Printz D. Society of Behavioral Medicine (SBM) position statement: restore CDC funding for firearms and gun violence prevention research. *Transl Behav Med*. 2018 Feb 21

[48] Wong, S. "GOP chairman: Congress should rethink CDC ban on gun violence research" *The Hill*. 15 February 2018 http://thehill.com/homenews/house/374149-gop-chairman-congress-should-rethink-cdc-ban-on-gun-violence-research Accessed 5 June 2018

[49] Smart, R. Mass Shootings: Definitions and Trends. RAND Corporation. https://www.rand.org/research/gun-policy/analysis/supplementary/mass-shootings.html Accessed 2 June 2018.

[50] Krouse, WJ, and Richardson DJ, Mass Murder with Firearms: Incidents and Victims, 1999–2013, Washington, D.C.: Congressional Research Service, R44126, 2015.

[51] Basu S, Meghani A, Siddiqi A. Evaluating the Health Impact of Large-Scale Public Policy Changes: Classical and Novel Approaches. *Annu Rev Public Health*. 2017;38:351-370.

[52] Drange, M. "The Kentucky gun owner who developed his own count of gun violence in the US". *The Guardian*. 23 April 2016. https://www.theguardian.com/world/2016/apr/23/kentucky-gun-owner-gun-violence-archive-mark-bryant Accessed 5 June 2018

[53] Murphy SL, Xu J, Kochanek KD, Curtin SA, Elizabeth Arias E. *National Vital Statistics Reports*. Volume 66, Number 6 November 27, 2017. Deaths: Final Data for 2015. Centers for Disease Control and Prevention.

Figure Titles

Figure 1: Mass Shooting Deaths. United States 1981 – 2017

Figure 2: Case Fatality per 100 Total Mass-Shooting Injuries with Loess Smoothing Line for Trend and Standard Error Bounds. United States 1981 – 2017.

Figure 3: Mass Shooting Deaths per 10,000 Firearm-Related Homicides with Linear Trends for Pre-Ban, Ban and Post-Ban Periods. U.S. 1981 – 2017

Figure 4: Mass-Shooting Shooting Deaths per 10,000 Firearm-Related Homicides Restricted to Incidents Involving Assault Weapons with Linear Trends for Pre-Ban, Ban and Post-Ban Periods. U.S. 1981 – 2017

Table 1: Linear Regression Effect of 1994-2004 Federal Assault Weapon Ban on Mass-Shooting Deaths per 10,000 Firearm Homicides. U.S., 1981 - 2017.

Table 2: Linear Regression Effect of 1994-2004 Federal Assault Weapon Ban on Mass-Shooting Deaths Characterized by use of Assault Weapon per 10,000 Firearm Homicides. U.S., 1981 - 20017.

Table 3: Exponentiated Coefficients Generalized Linear Poisson Model. Effect of 1994-2004 Federal Assault Weapon Ban on Mass-Shooting Death Counts. United States, 1981 - 20017.

Figure 1

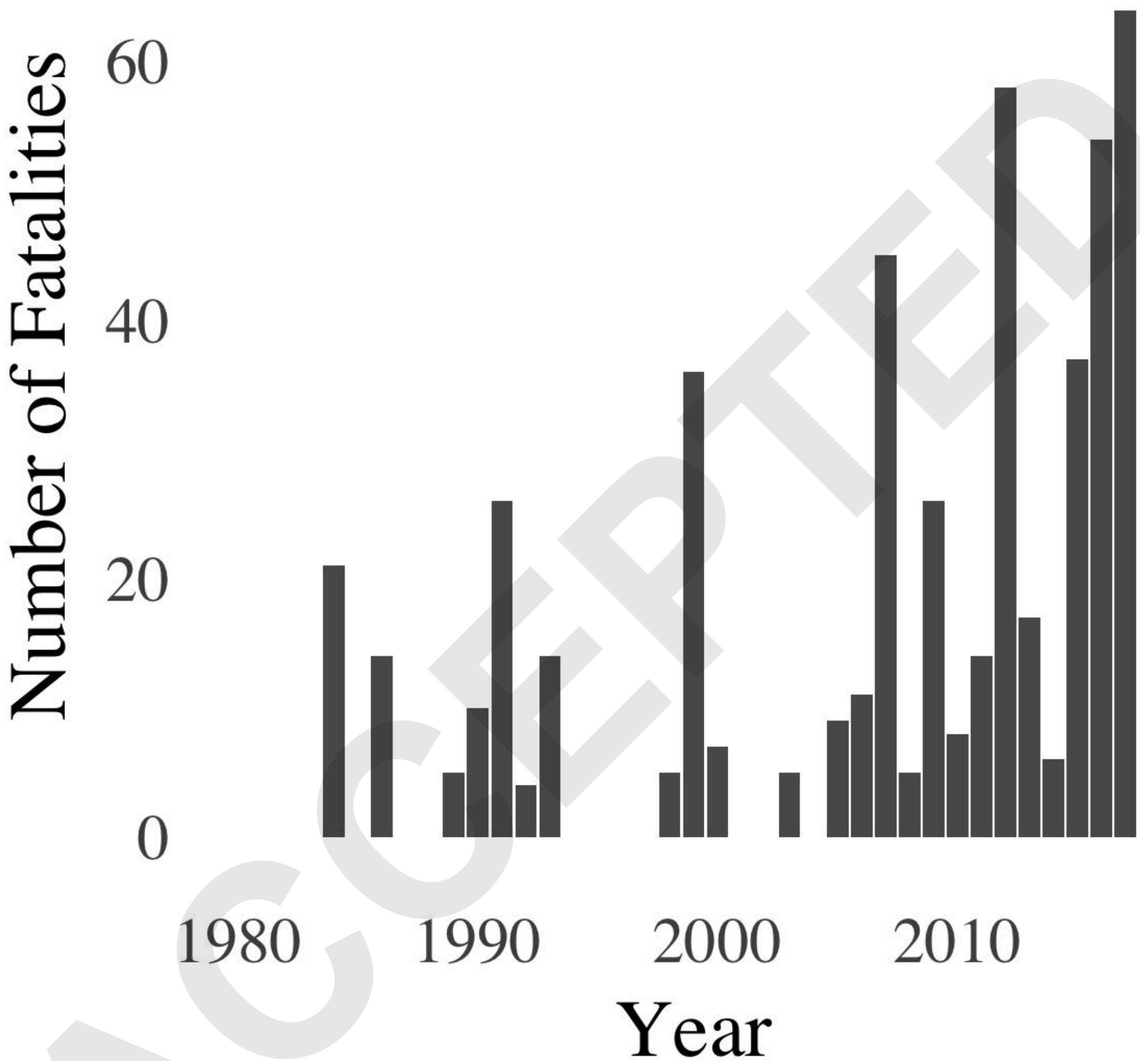


Figure 2

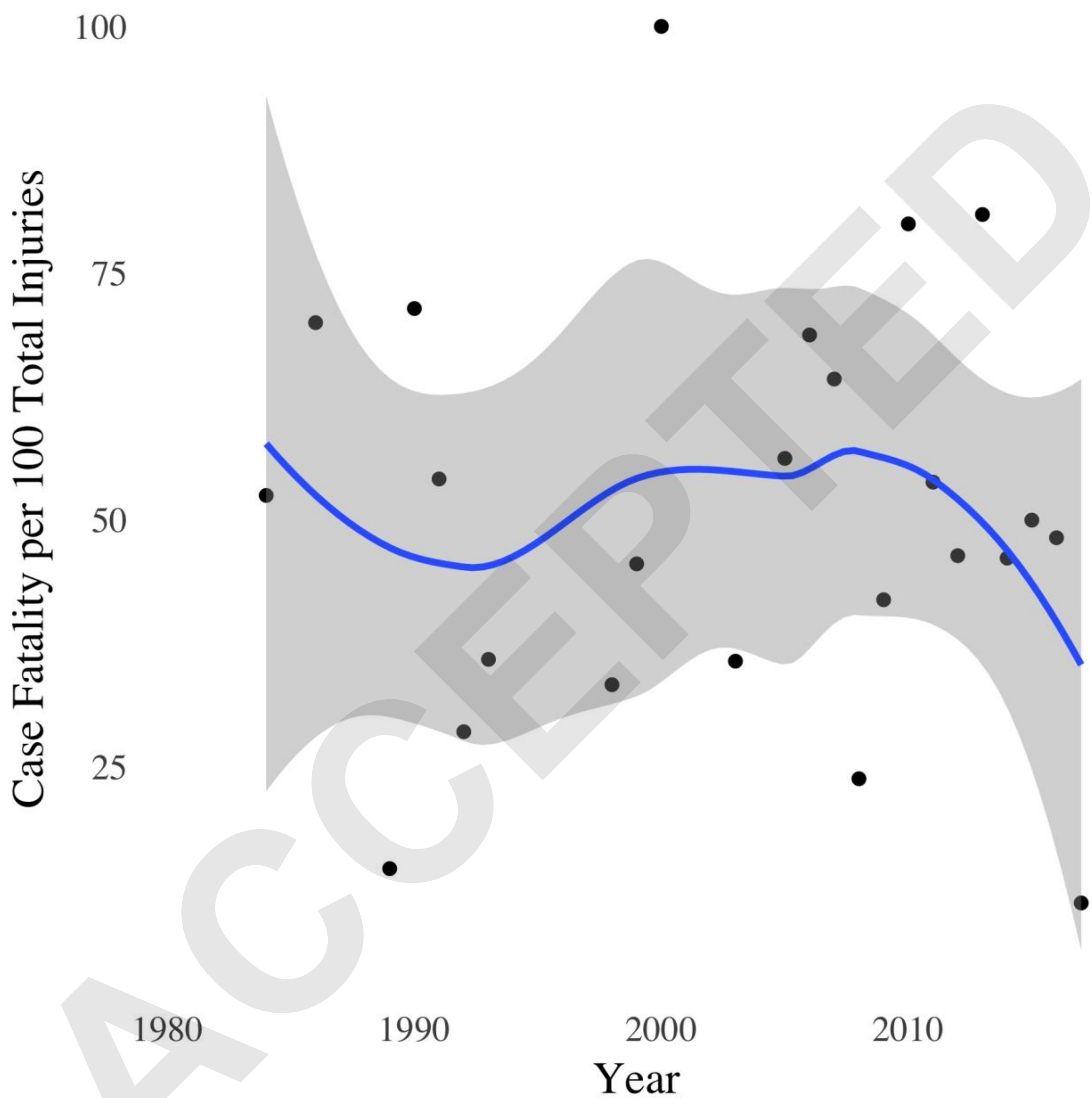

100
75
50
25
Case Fatality per 100 Total Injuries
1980
1990
2000
2010
Year

Figure 3

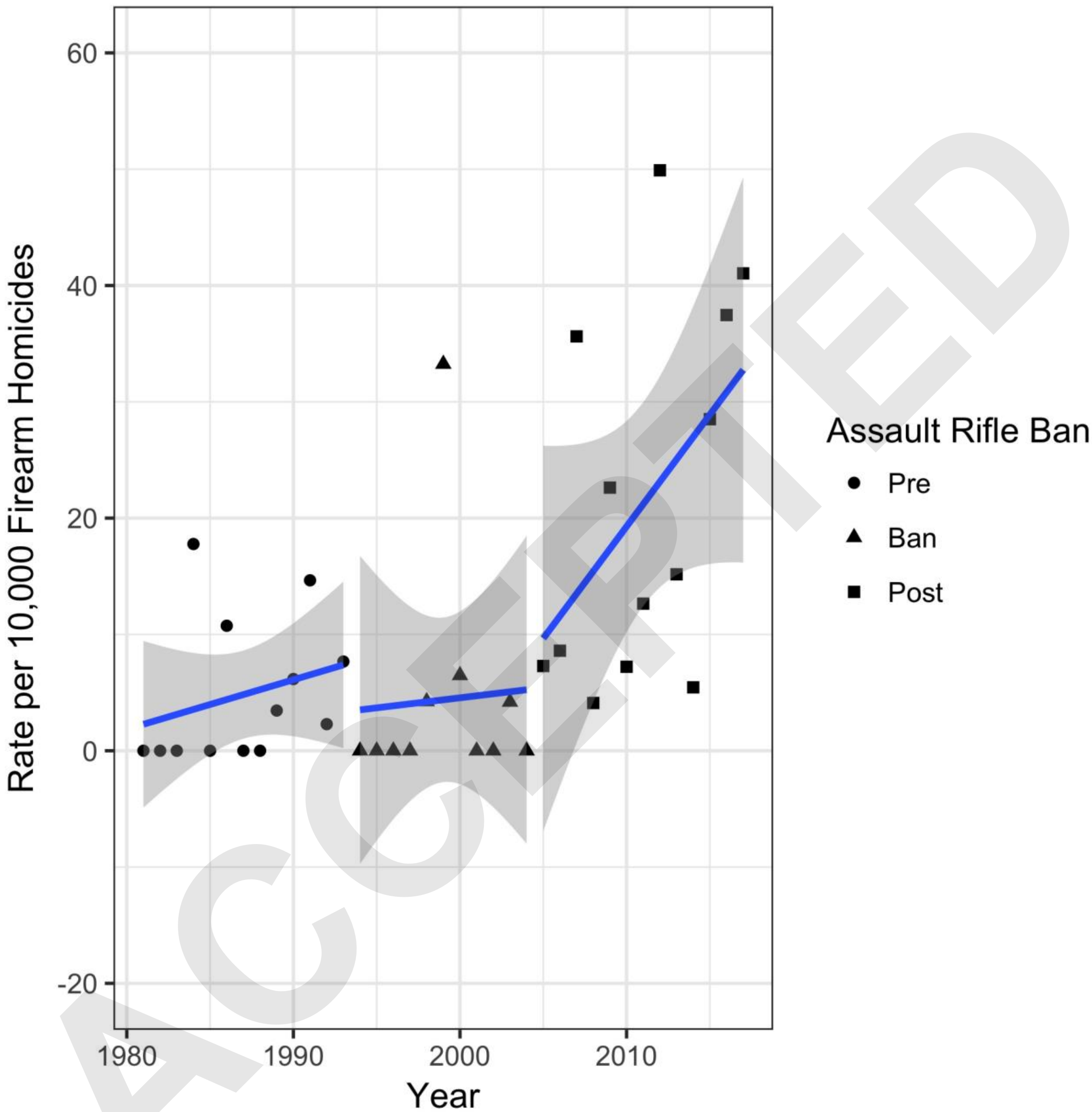
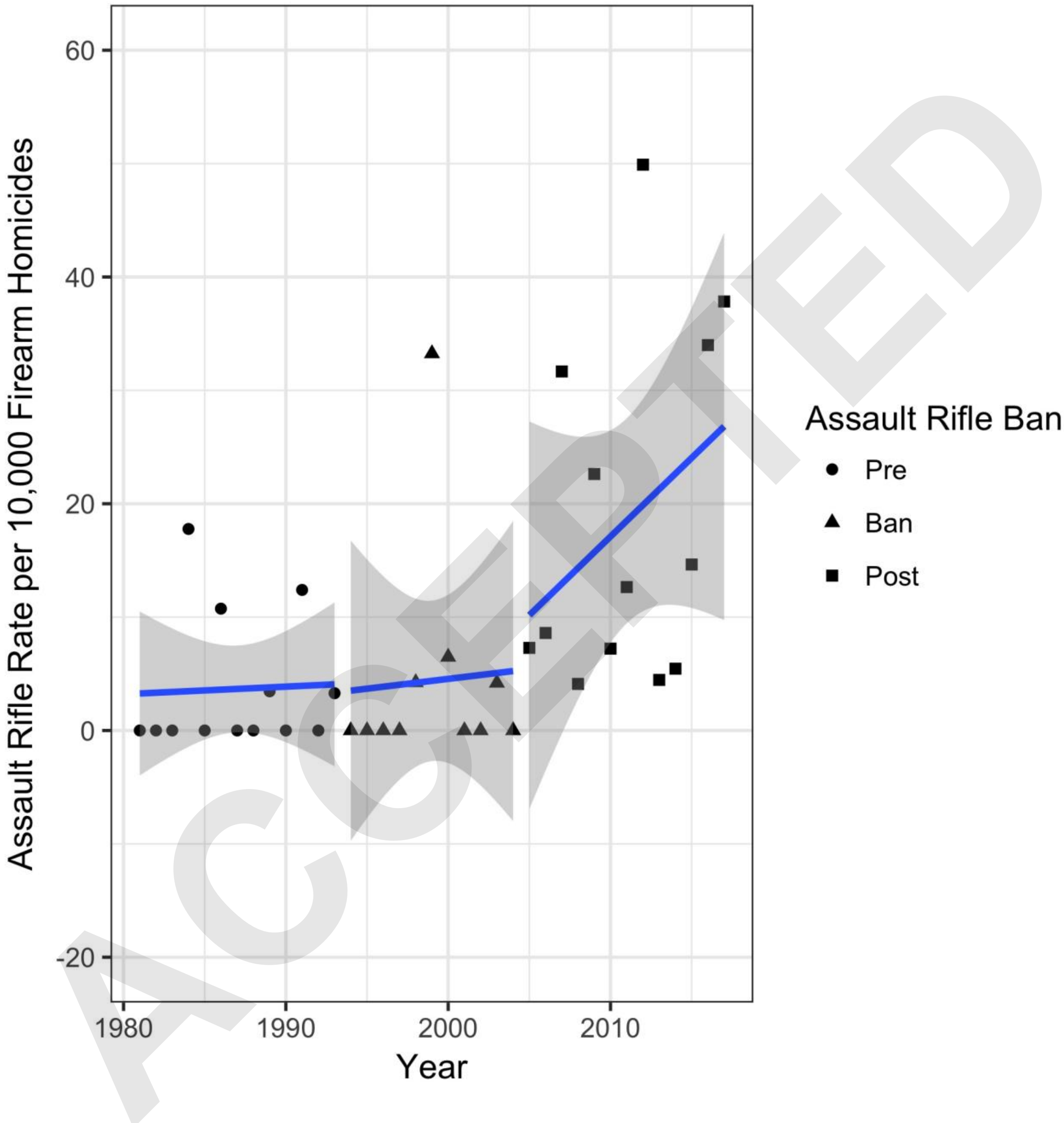

60
40
20
0
-20
Rate per 10,000 Firearm Homicides
1980
1990
2000
2010
Year
Assault Rifle Ban
Pre
Ban
Post

Figure 4


60
40
20
0
-20
1980
1990
2000
2010
Year
Assault Rifle Rate per 10,000 Firearm Homicides
Assault Rifle Ban
Pre
Ban
Post
ACCEPTED

Variable	Estimate	Std. Error	t value	p
(Intercept)	-1409.4	333.0	-4.2	0.0002
Year	0.7	0.2	4.3	0.0001
Ban Period	-8.6	3.9	-2.2	0.03

Variable	Estimate	Std. Error	t value	p
(Intercept)	-1219.7	333.9	-3.7	0.0009
Year	0.6	0.2	3.7	0.0008
Ban	-6.7	3.9	-1.7	0.09

	Homicide Offset		Population Offset	
Variable	Estimate	95% CI	Estimate	95% CI
Year	0.6	0.2	3.7	0.0008
Ban	-6.7	3.9	-1.7	0.09