The Effectiveness of the 1994-2004 Federal Assault Weapon Ban in Controlling Mass Shooting Deaths: Analysis of Open-Source Data Analytic Code and Notes

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1 Methods

Mass incident shooting data were obtained from 3 independent, well-documented and referenced online sources. These sources have each been the basis for a number of previous studies.Data from the 3 online open-source references were combined. Analyses were restricted to only those incidents reported by all three sources. Entries were further restricted to just those for which 4 or more fatalities, not including the shooter, were reported. Yearly homicide data were obtained from the US Centers for Disease Control and Prevention WISQARS (Web-based Injury Statistics Query and Reporting System) an online database of fatal and nonfatal injury. 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. A variable was created to indicate the 1994 to 2004 period as the federal ban period. 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. The total number of mass shooting fatalities and injuries were aggregated by year and merged to 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 the total and yearly number of mass-shooting incidents that met the strictest criteria and were confirmed by all three sources, the number of all-weapon mass-shooting fatalities, and 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 plotted the yearly rate of mass shooting fatalities per 10,000 firearm-related homicides with an overlying simple linear model with year as the only predictor for the total time period, and for pre-ban, ban and post-ban time periods. We tested the hypothesis that the federal ban period was associated with an decrease in the number and rate of mass-shooting fatalities in the United States with a multiple linear regression model, with 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. An unadjusted dichotomous odds ratio was calculated to measure the strength of the association of the Federal ban period with the proportion of all firearm-related homicides accounted for by mass-shootings. All results are presented with two-sided p-values with an alpha of 0.05 and/or 95% confidence intervals. A similar subgroup analysis was conducted with data restricted to incidents in which an assault-type weapon was explicitly noted.

The study was determined to be exempt as non-identifiable data. The study data and analytic code are available for download at xxxxxxxxxx.

```
# ALL MASS SHOOTINGS CONFIRMED FROM 3 SOURCES

shootings <- read.csv("~/data/confirmedX3.csv", header = T, stringsAsFactors = F)
str(shootings)
names(shootings)
sum(shootings$Fatalities > 3)

# restrict to 4 or greater deaths
shootings <- shootings[shootings$Fatalities > 3, ]

# create 'total' variable of fatalities plus injuries
shootings$total <- shootings$Injured + shootings$Fatalities

# aggregate fatalities and total to yearly
year.dat <- aggregate(shootings[c("Fatalities", "total")], list(shootings$Year),
    sum)
names(year.dat) <- c("Year", "Fatalities", "Total")

# read in cdc homicide data
homicides9916 <- read.csv("~/Data/cdcGunHomicides9916.csv", header = T,
    stringsAsFactors = F)
homicides8198 <- read.csv("~/Data/cdcGunHomicides8198.csv", header = T,
    stringsAsFactors = F)
deaths <- rbind(homicides9916[-19, c("Year", "Deaths", "Population")],
    homicides8198[-19, c("Year", "Deaths", "Population")])
```

```r
# merge mass shooting and total firearm homicide data
yearlyDat <- merge(year.dat, deaths, by = "Year", all.y = T,
    all.x = T)

# add 2017 homicide deaths and US population estimates
yearlyDat$Deaths[37] <- 15593
yearlyDat$Population[37] <- 327200000

# convert NAs from years where no mass shootings to zeros
yearlyDat$Fatalities[is.na(yearlyDat$Fatalities)] <- 0
yearlyDat$Total[is.na(yearlyDat$Total)] <- 0

# create rate variable (mass shooting deaths by total firearm
# homicide deaths)
yearlyDat$Rate <- yearlyDat$Fatalities/yearlyDat$Deaths * 10000

# create assualt weapon ban period indicator
yearlyDat$Ban1 <- 0
yearlyDat$Ban1[yearlyDat$Year %in% 1994:2004] <- 1
yearlyDat$Ban2 <- 0
yearlyDat$Ban2[yearlyDat$Year %in% 1994:2004] <- 1
yearlyDat$Ban2[yearlyDat$Year %in% 2005:2018] <- 2



# ASSAULT WEAPON MASS SHOOTINGS CONFIRMED FROM 3 SOURCES

assaultIndicator <- grep(c("AK|AR|MCX|assault|Assault|semiautomatic"),
    shootings$Weapon.details)
length(assaultIndicator)  # 34
shootings$Assault <- 0
shootings$Assault[assaultIndicator] <- 1
table(shootings$Assault)
assault.shootings <- shootings[shootings$Assault == 1, ]

# YEARLY ASSAULT WEAPONS FATALITIES DATA
assault.dat <- aggregate(assault.shootings[c("Fatalities", "total")],
    list(assault.shootings$Year), sum)
names(assault.dat) <- c("Year", "Assault.Fatalities", "Assault.Total")

# merge to all-weapons total fatality data

yearlyDat <- merge(yearlyDat, assault.dat, by = "Year", all.y = T,
    all.x = T)

# replace NAs with 0s
yearlyDat$Assault.Fatalities[is.na(yearlyDat$Assault.Fatalities)] <- 0
yearlyDat$Assault.Total[is.na(yearlyDat$Assault.Total)] <- 0

# calculate rates
yearlyDat$Assault.Rate <- yearlyDat$Assault.Fatalities/yearlyDat$Deaths *
    10000

yearlyDat
table(assault.dat$Year)


# save file
write.csv(yearlyDat, "~/data/yearlyDat.csv")
```

2 Results

The three data sources listed incidents ranging from 1981 to 2017. There were a total of 51 reported cases of mass shootings 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 and 1,460 total all-weapon fatalities and injuries over the 37-year period, for a total case-fatality ratio of 34.3% (95% CI 31.9, 36.8). During this same period, there were a total of 489,043 firearm-related homicides in the United States. The overall rate of mass shooting fatalities per 10,000 firearm-related homicides was 10.2 (95% CI 9.4, 11.2). There was graphical evidence of an overall increase in the all-weapon yearly number of mass-shooting fatalities in the United States during the study period, with some evidence of a decrease in case fatality in the post 2010 period. 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.

```r
# read in data
yearlyDat <- read.csv("~/data/yearlyDat.csv", header = T, stringsAsFactors = F)

# ALL WEAPONS

sum(yearlyDat$Fatalities)  # 501
sum(yearlyDat$Total)  # 1460

sum(yearlyDat$Fatalities)/sum(yearlyDat$Total) * 100  #34.31507
library(binom)
binom.confint(sum(yearlyDat$Fatalities), sum(yearlyDat$Total)) *
    100
# method x n mean lower upper 1 NA 50100 146000 34.31507
# 31.92346 36.78900 2 NA 50100 146000 34.31507 31.87980
# 36.75034 3 NA 50100 146000 34.32580 31.89861 36.76503 4 NA
# 50100 146000 34.31507 31.88735 36.75408 5 NA 50100 146000
# 34.31507 31.87916 36.81425 6 NA 50100 146000 34.31507
# 31.92267 36.78987 7 NA 50100 146000 34.31507 31.91383
# 36.78139 8 NA 50100 146000 34.31507 31.90881 36.77631 9 NA
# 50100 146000 34.31507 31.90947 36.77651 10 NA 50100 146000
# 34.31507 31.89023 36.82338 11 NA 50100 146000 34.31507
# 31.92381 36.78865


sum(yearlyDat$Deaths)  # 489043
sum(yearlyDat$Fatalities)/sum(yearlyDat$Deaths) * 10000  # 10.2445



binom.confint(sum(yearlyDat$Fatalities), sum(yearlyDat$Deaths)) *
    10000
# method x n mean lower upper 1 NA 5010000 4890430000 10.2445
# 9.385387 11.18200 2 NA 5010000 4890430000 10.2445 9.347901
# 11.14110 3 NA 5010000 4890430000 10.2547 9.363933 11.15691
# 4 NA 5010000 4890430000 10.2445 9.380773 11.17531 5 NA
# 5010000 4890430000 10.2445 9.367364 11.18158 6 NA 5010000
# 4890430000 10.2445 9.385980 11.18145 7 NA 5010000
# 4890430000 10.2445 9.383049 11.17797 8 NA 5010000
# 4890430000 10.2445 9.373845 11.16742 9 NA 5010000
# 4890430000 10.2445 9.634146 11.26440 10 NA 5010000
# 4890430000 10.2445 9.376465 11.19181 11 NA 5010000
# 4890430000 10.2445 9.386243 11.18114

plot(yearlyDat$Year, yearlyDat$Fatalities, type = "h")
```

```r
qplot(yearlyDat$Year, yearlyDat$Fatalities, geom = "bar")


library(ggplot2)
library(ggthemes)

# plot yearly deaths

p1 <- ggplot(data = yearlyDat, aes(x = Year, y = Fatalities))
p2 <- p1 + geom_bar(stat = "identity") + ylim(0, 70)
p3 <- p2 + theme_tufte(base_size = 14, ticks = F) + ylab("Number of Fatalities")
ggsave("~/jtacsWriteup/fatalitiesBar.jpg", p3)

# plot yearly case fatality

p1 <- ggplot(data = yearlyDat, aes(x = Year, y = Fatalities/Total *
    100))
p2 <- p1 + geom_point() + geom_smooth()
p3 <- p2 + theme_tufte(base_size = 14, ticks = F) + ylab("Case Fatality per 100 Total Injuries")
ggsave("~/jtacsWriteup/CFR.jpg", p3)


# ASSAULT WEAPONS AS PROPORTION OF ALL MASS SHOOTING
# FATALITIES
sum(yearlyDat$Assault.Fatalities)  # 430
binom.confint(sum(yearlyDat$Assault.Fatalities), sum(yearlyDat$Fatalities)) *
    100

# method x n mean lower upper 1 NA 43000 50100 85.82834
# 82.48922 88.62222 2 NA 43000 50100 85.82834 82.77444
# 88.88224 3 NA 43000 50100 85.75697 82.67189 88.76191 4 NA
# 43000 50100 85.82834 82.45762 88.59648 5 NA 43000 50100
# 85.82834 82.46328 88.76310 6 NA 43000 50100 85.82834
# 82.49181 88.61677 7 NA 43000 50100 85.82834 82.55081
# 88.66140 8 NA 43000 50100 85.82834 82.59483 88.69640 9 NA
# 43000 50100 85.82834 82.59488 88.69639 10 NA 43000 50100
# 85.82834 82.39341 88.70034 11 NA 43000 50100 85.82834
# 82.50127 88.61017


# yearly assault weapons proportions
assault.prop <- yearlyDat$Assault.Fatalities/yearlyDat$Fatalities *
    100
assault.prop <- assault.prop[!is.na(assault.prop)]
sum(assault.prop == 100)
length(assault.prop)
sum(assault.prop == 100)/length(assault.prop) * 100
binom.confint(sum(assault.prop == 100), length(assault.prop)) *
    100
# method x n mean lower upper 1 NA 1500 2400 62.5 42.63913
# 78.91146 2 NA 1500 2400 62.5 43.13141 81.86859 3 NA 1500
# 2400 62.0 43.31398 80.16779 4 NA 1500 2400 62.5 40.30197
# 78.42091 5 NA 1500 2400 62.5 40.59364 81.20071 6 NA 1500
# 2400 62.5 42.17563 79.20322 7 NA 1500 2400 62.5 42.38154
# 79.65669 8 NA 1500 2400 62.5 42.58821 79.86949 9 NA 1500
# 2400 62.5 42.58785 79.87026 10 NA 1500 2400 62.5 40.75759
# 80.44981 11 NA 1500 2400 62.5 42.70996 78.84063
```

Between 1981 and 2017 mass shootings in the United States 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 Federal Weapons Ban was in effect, this slope appeared to decrease. . There was a dramatic increase in the yearly slope of mass-shooting homicides in the post-ban period. A similar pattern was evident in data restricted to those incidents characterized as involving assault weapons. 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. 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 of the 9 preventable deaths during the ban period were due to assault weapons alone. The unadjusted odds 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 more than 70% less likely to occur during the Federal ban period.