Predicting Firearm Mortality

What role does State Firearm Laws play?

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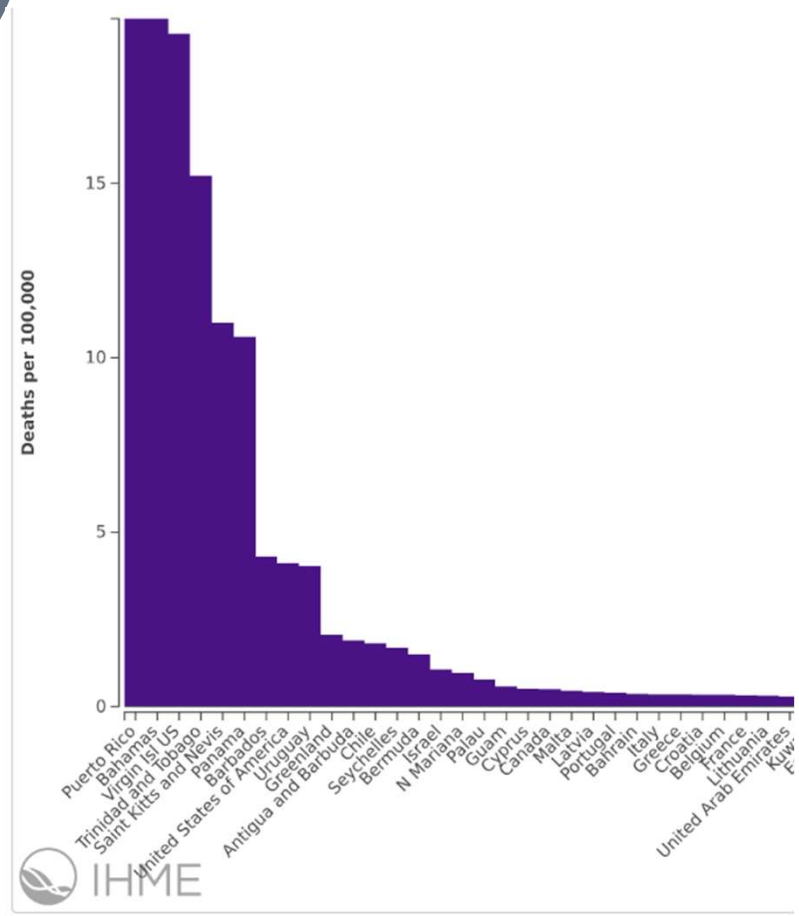


(Graph source: GBD Compare (ihmeuw.org/5f6r)

Overview

Background: In 2019, the U.S. ranked eighth out of 64 high-income countries & territories for homicides by firearm with Puerto Rico and the US Virgin Islands, two US territories, ranking first and third.

Research Question: Are there aspects of gun policy in the U.S. that predict firearm mortality rate?

https://www.healthdata.org/acting-data/gun-violence-united-states-outlier

Data - https://github.com/JAbinette/CUNY-607-Final-Project

- **U.S. Cause of Death by Firearm**
  - Queried from CDC https://wonder.cdc.gov grouped by State, Year and Cause of Death excluding Terrorism, Legal Intervention and Operations of War
  - 458 observations for 11 variables
  - '0 - wonder.cdc.gov Underlying Cause of Death cdc - Grp by State, ICD Sub-Chapter.txt'
- **Firearm Laws by State**
  - Database published on https://www.statefirearmlaws.org/resources containing detailed annual information on firearm-related laws in place
  - 1500 observations for 137 variables
  - '0 - statefirearmlaws.org Firearm Laws - DATABASE_0.xlsx'

Transformation - Firearm Laws by State

134 of 137 variables are specific provisions part of 14 categories

```
tibble [1,500 × 137] (S3: tbl_df/tbl/data.frame)
 $ state                          : chr [1:1500] "Alabama"
 $ year                           : num [1:1500] 1991 1992
 $ felony                         : num [1:1500] 0 0 0 0 0
 $ invcommitment                  : num [1:1500] 0 0 0 0 0
 $ invoutpatient                  : num [1:1500] 0 0 0 0 0
 $ danger                         : num [1:1500] 0 0 0 0 0
 $ drugmisdemeanor                : num [1:1500] 0 0 0 0 0
 $ alctreatment                   : num [1:1500] 0 0 0 0 0
 $ alcoholism                     : num [1:1500] 1 1 1 1 1
 $ relinquishment                 : num [1:1500] 0 0 0 0 0
 $ violent                        : num [1:1500] 0 0 0 0 0
 $ violenth                       : num [1:1500] 0 0 0 0 0
 $ violentpartial                 : num [1:1500] 0 0 0 0 0
 $ dealer                         : num [1:1500] 0 0 0 0 0
 $ dealerh                        : num [1:1500] 1 1 1 1 1
 $ recordsall                     : num [1:1500] 0 0 0 0 0
 $ recordsallh                    : num [1:1500] 1 1 1 1 1
```

```
'data.frame':   134 obs. of  4 variables:
 $ Category.Code: int  1 1 1 1 1 1 1 1 1 1 ...
 $ Category     : chr  "Dealer regulations" "Dealer regulations" "Dealer re
 $ Sub.Category : chr  "Licensing" "Licensing" "Recordkeeping" "Recordkeep
 $ Variable.Name: chr  "dealer" "dealerh" "recordsdealer" "recordsdealerh"
```

The absence/presence of 134 provisions of law were rolled up to the sum of present provisions for each category

=

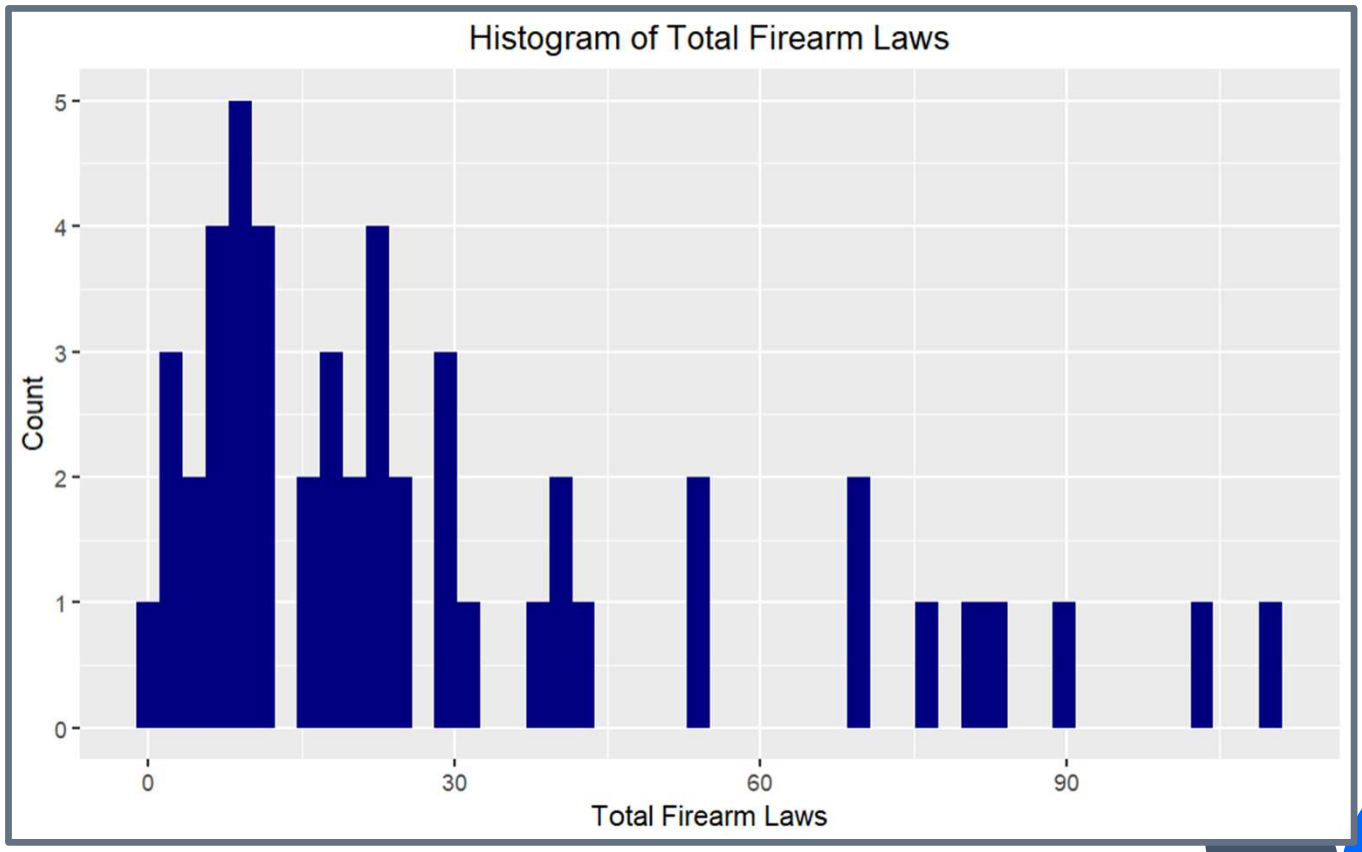
```
tibble [50 × 17] (S3: tbl_df/tbl/data.frame)
 $ state                                 : chr [1:50] "Alabama" "
 $ year                                  : num [1:50] 2020 2020 2
 $ lawtotal                              : num [1:50] 10 3 8 11 1
 $ Concealed.carry.permitting            : int [1:50] 4 0 0 5 6 5
 $ Dealer.regulations                    : int [1:50] 1 0 0 0 14
 $ Domestic.violence                     : int [1:50] 2 0 3 0 18
 $ Prohibitions.for.high.risk.gun.possession : int [1:50] 3 1 4 3 8 1
 $ Buyer.regulations                     : int [1:50] 0 1 0 0 14
 $ Possession.regulations                : int [1:50] 0 1 1 2 8 4
 $ Stand.your.ground                     : int [1:50] 0 0 0 1 1 1
 $ Ammunition.regulations                : int [1:50] 0 0 0 0 5 0
 $ Assault.weapons.and.large.capacity.magazines: int [1:50] 0 0 0 0 8 1
 $ Background.checks                     : int [1:50] 0 0 0 0 11
 $ Child.access.prevention               : int [1:50] 0 0 0 0 9 0
 $ Gun.trafficking                       : int [1:50] 0 0 0 0 6 2
 $ Immunity                              : int [1:50] 0 0 0 0 1 0
 $ Preemption                            : int [1:50] 0 0 0 0 2 0
```

Simple Linear Regression

Can the Total # of Firearm Laws Predict Proportion of Firearm Deaths per State Population?

```
   State            Prop.of.Pop         Prop.of.Deaths       lawtotal
Length:50          Min.   :0.0000334   Min.   :0.00387   Min.   :  1.00
Class :character   1st Qu.:0.0001093   1st Qu.:0.01078   1st Qu.:  9.25
Mode  :character   Median :0.0001390   Median :0.01360   Median : 20.50
                   Mean   :0.0001473   Mean   :0.01390   Mean   : 29.44
                   3rd Qu.:0.0001920   3rd Qu.:0.01736   3rd Qu.: 40.50
                   Max.   :0.0002744   Max.   :0.03095   Max.   :111.00
```

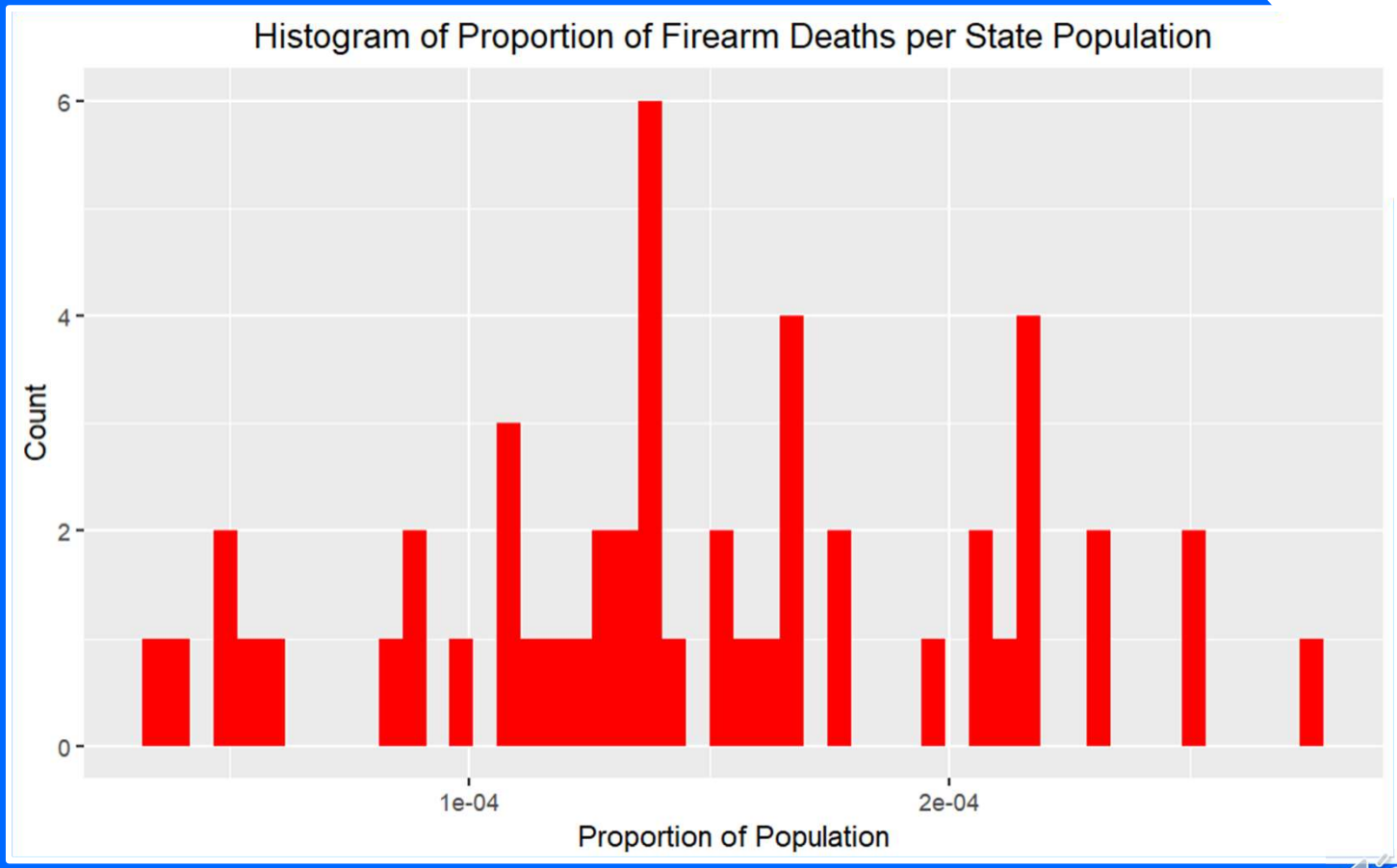
Firearm Laws



Mean	29.44
Median	20.50
Std Dev	28.24
IQR	31.25

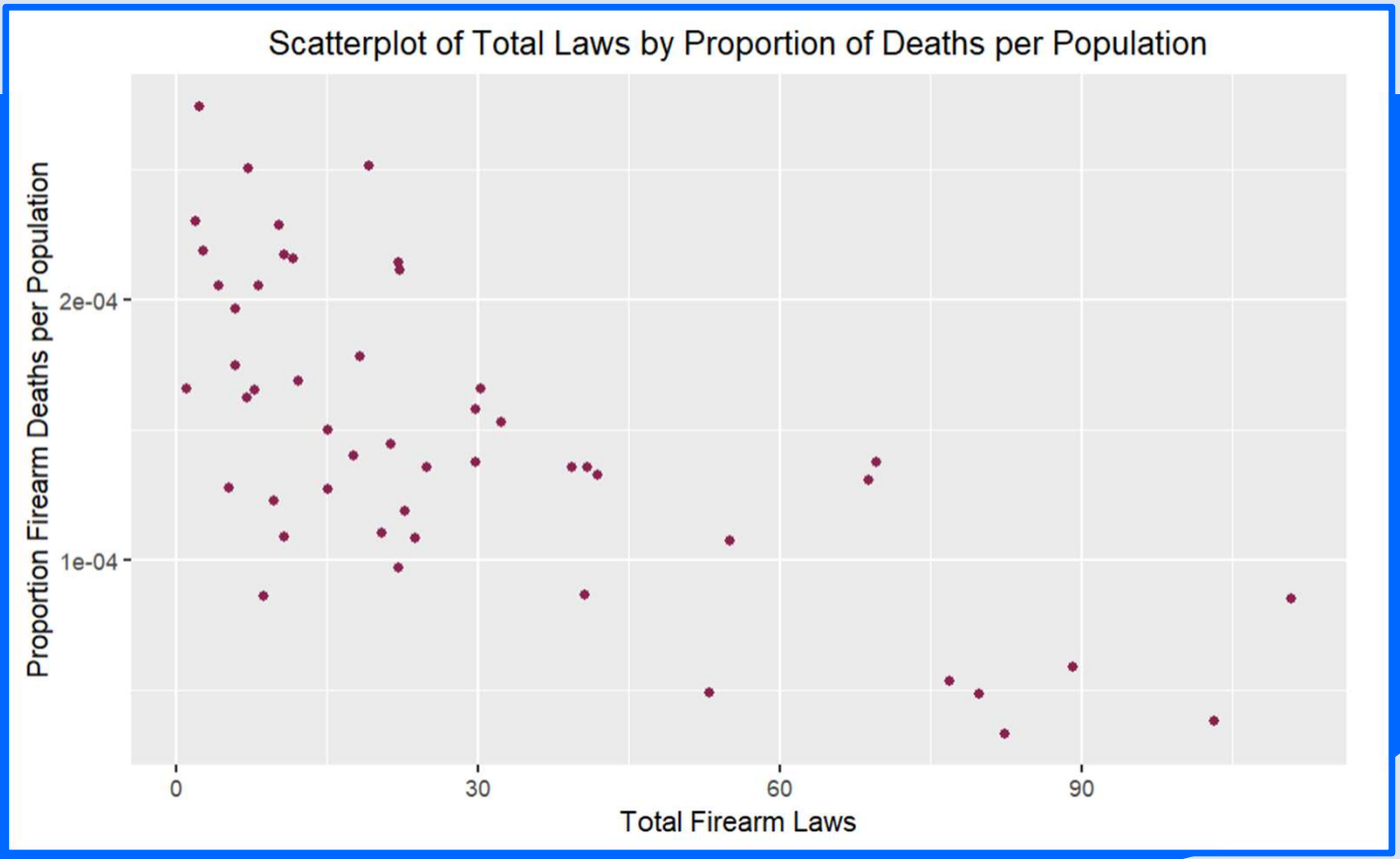
Proportion of Population

Mean	.0001473
Median	.0001390
Std Dev	5.909e-05
IQR	8.262e-05



Total Firearm Laws x Proportion of Population

Correlation
-.702



Simple Linear Regression

$\widehat{\text{Proportion of Population}} = 1.906e\text{-}04 - 1.470e\text{-}06 \times \text{Law.Total}$

```
lm(formula = Prop.of.Pop ~ lawtotal, data = df)

Residuals:
       Min         1Q     Median         3Q        Max
-9.100e-05 -2.413e-05 -1.467e-06  3.114e-05  8.876e-05

Coefficients:
```

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.906e-04	8.727e-06	21.840	< 2e-16	***
lawtotal	-1.470e-06	2.149e-07	-6.837	1.31e-08	***

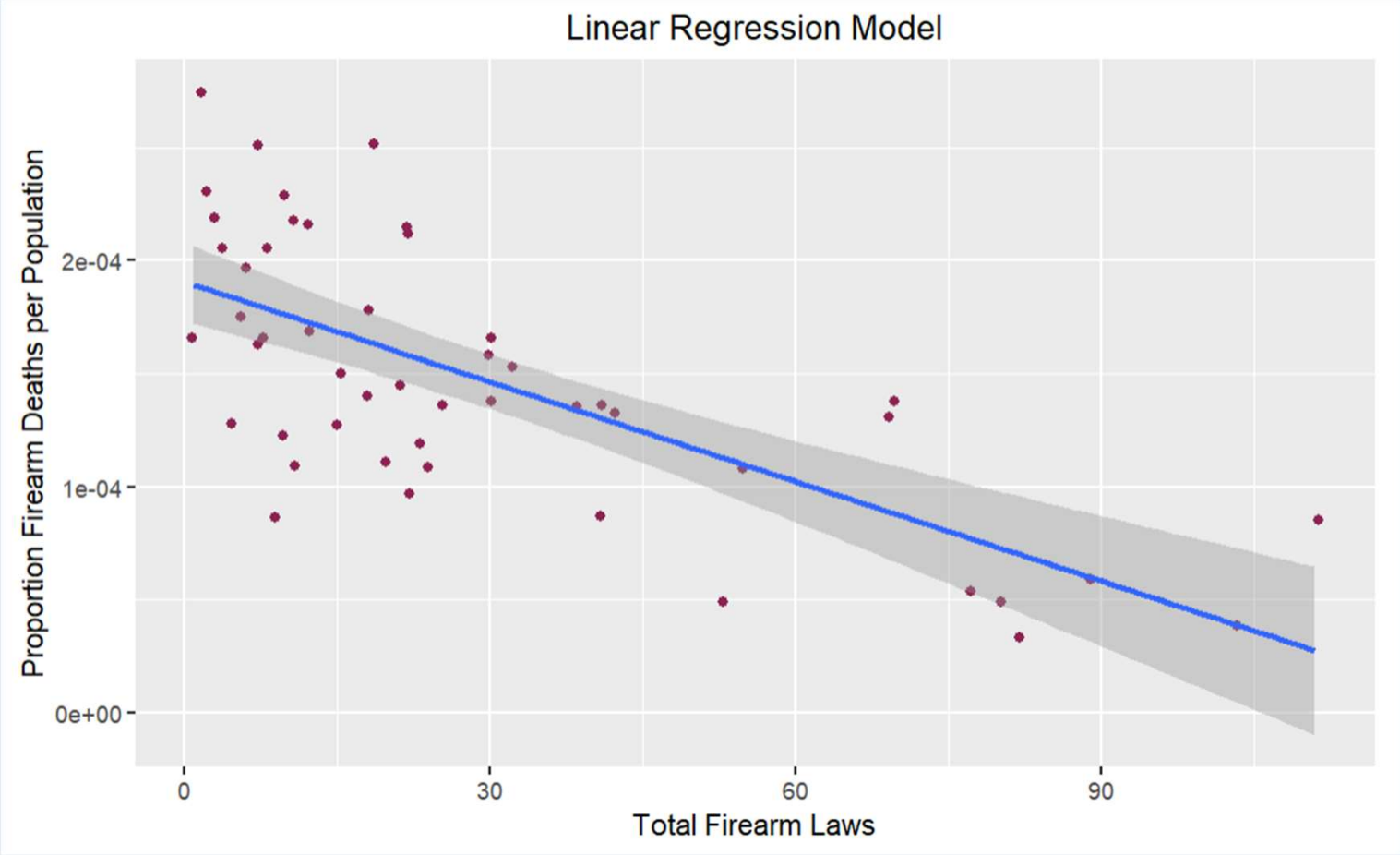
```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘

Residual standard error: 4.249e-05 on 48 degrees of freedom
Multiple R-squared:  0.4934,    Adjusted R-squared:  0.4829
F-statistic: 46.75 on 1 and 48 DF,  p-value: 1.305e-08
```

Total number of firearm laws is a statistically significant predictor of Proportion of Firearm Deaths per Population

R-squared indicates the model accounts for 49.34% of the variability.

Can We Make a Better Model?



Multiple Linear Regression

Can the Number & Category of Laws predict proportion of Firearm deaths per State Population?

Category	Provisions	Mean	Median
Domestic violence	21	5.64	3.50
Buyer regulations	17	2.76	1.00
Dealer regulations	17	2.78	0.50
Possession regulations	12	3.02	2.50
Background checks	11	3.20	0.00
Prohibitions for high-risk gun possession	11	3.26	3.00
Child access prevention	11	1.90	0.00
Assault weapons and large-capacity magazines	8	0.80	0.00
Concealed carry permitting	7	3.38	4.00
Ammunition regulations	7	0.72	0.00
Gun trafficking	7	0.78	0.00
Preemption	3	0.40	0.00
Stand your ground	1	0.44	0.00
Immunity	1	0.34	0.00

Multiple Linear Regression - Full Model

```
Residuals:
       Min         1Q     Median         3Q        Max
-6.912e-05 -1.866e-05 -4.747e-06  2.022e-05  9.049e-05

Coefficients:
                                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                                    1.749e-04  1.387e-05  12.612 1.41e-14 ***
Concealed.carry.permitting                     1.298e-06  3.768e-06   0.344   0.7326
Dealer.regulations                            -5.773e-07  3.243e-06  -0.178   0.8597
Domestic.violence                             -1.357e-06  2.295e-06  -0.591   0.5582
Prohibitions.for.high.risk.gun.possession      1.717e-06  3.894e-06   0.441   0.6620
Buyer.regulations                             -4.398e-06  3.330e-06  -1.321   0.1951
Possession.regulations                         7.210e-06  4.265e-06   1.690   0.0998 .
Stand.your.ground                             -3.039e-05  2.141e-05  -1.420   0.1645
Ammunition.regulations                         1.221e-05  1.024e-05   1.192   0.2414
Assault.weapons.and.large.capacity.magazines   3.794e-06  5.031e-06   0.754   0.4558
Background.checks                             -7.961e-07  2.845e-06  -0.280   0.7813
Child.access.prevention                       -8.916e-06  3.997e-06  -2.231   0.0322 *
Gun.trafficking                               -8.205e-06  7.430e-06  -1.104   0.2770
Immunity                                      -1.213e-06  2.057e-05  -0.059   0.9533
Preemption                                    -2.533e-05  1.217e-05  -2.082   0.0447 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.141e-05 on 35 degrees of freedom
Multiple R-squared:  0.6493,    Adjusted R-squared:  0.509
F-statistic: 4.628 on 14 and 35 DF,  p-value: 0.0001146
```

Adjusted R-squared indicates the model accounts for 50.9% of the variability, but many predictors are not statistically significant

Multiple Linear Regression –

Backward-Selection

```
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              1.842e-04  7.847e-06  23.480  < 2e-16 ***
Stand.your.ground       -3.813e-05  1.314e-05  -2.902  0.00567 **
Child.access.prevention -6.860e-06  2.492e-06  -2.753  0.00843 **
Preemption              -1.777e-05  7.425e-06  -2.393  0.02083 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.982e-05 on 46 degrees of freedom
Multiple R-squared:  0.5737,    Adjusted R-squared:  0.5459
F-statistic: 20.64 on 3 and 46 DF,  p-value: 1.284e-08
```

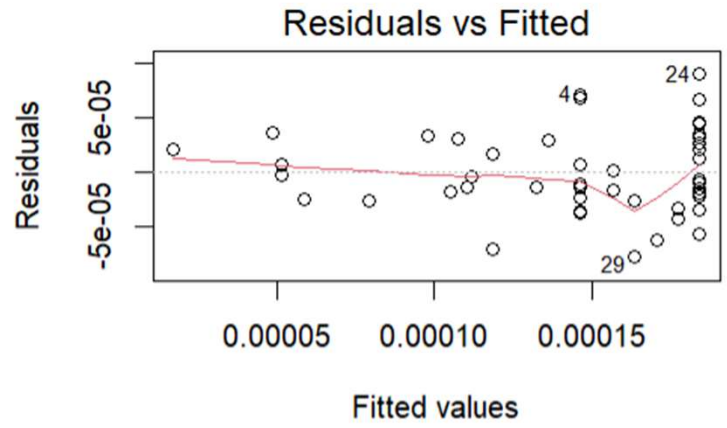
Adjusted R-squared increased ~4% to account for **54.6%** of the variability

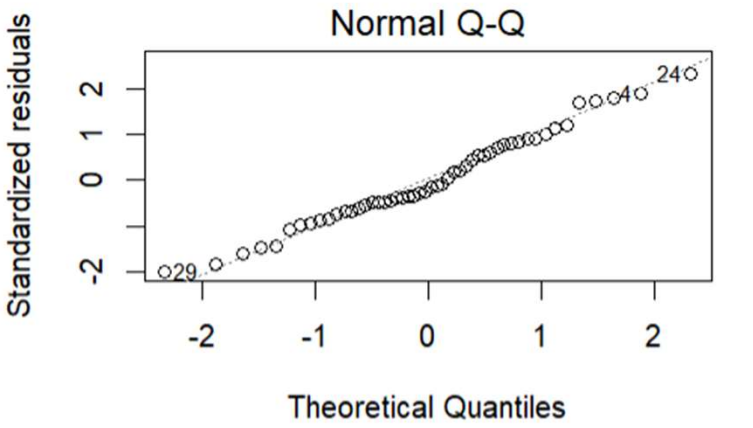
1.842e-04

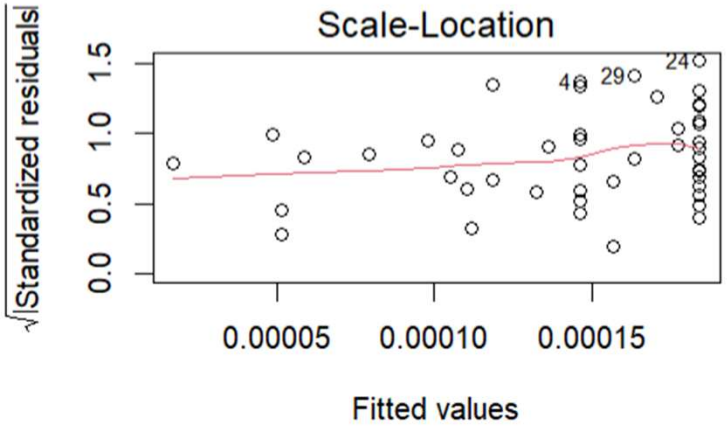
- **3.813e-05 x Stand.Your.Ground**
- **6.860e-06 x Child.Access.Prevention**
- **1.777e-05 x Preemption**

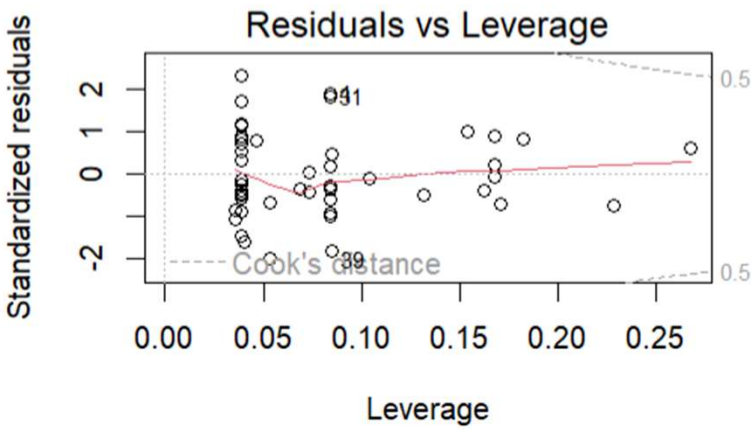
Multiple Regression Model Conditions

1. Residuals are **Nearly Normal**
2. Variability of the Residuals is **Nearly Constant**
3. Residuals are **Independent**
4. Each Variable is **Linearly Related** to the Outcome


Residuals vs Fitted
Residuals
Fitted values
0.00005
0.00010
0.00015
-5e-05
5e-05
24
40
29


Normal Q-Q
Standardized residuals
Theoretical Quantiles
-2
-1
0
1
2
24
40
29


Scale-Location
√|Standardized residuals|
Fitted values
0.00005
0.00010
0.00015
0.0
0.5
1.0
1.5
24
40
29


Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.00
0.05
0.10
0.15
0.20
0.25
0.5
0.5
41
39

Conclusion

Are there aspects of gun policy in the U.S. that predict firearm mortality rate?

Total number of firearm laws is a significant predictor and accounts for 49% of the variability in Firearm Deaths as a Proportion of the State Population

In breaking down the firearm laws by category, a multiple regression analysis determined that the number of Stand Your Ground, Child Access Prevention, and Preemption firearm laws can explain 55% of the variability.

Satisfaction of model conditions may be questionable as slight normality issues in residual plots

Future analysis could explore firearm provisions in more detail and comparing by year the changes in State firearm laws and the affect on firearm mortality

Thank you