Comparative Analysis of Firearm Ownership and Crime Rates Across U.S. States

I. INTRODUCTION

Firearm ownership is always a controversial topic in the United States, where the right to bear arms is protected by the Constitution. However, individual states vary greatly in the regulations they impose on firearm ownership. The strict states typically require more extensive processes and tests to obtain firearm permits. This project analyses the correlation between firearm ownership, regulation strictness, and crime rates across various U.S. states. States like "California", "Massachusetts" and "New York" have strict regulations, while "Texas", "Alaska" and "Wyoming" are more lenient.

By comparing data from both types of states, we aim to identify patterns, offering insights into the relationship between gun ownership and crime. In other words, this project seeks to answer:

"How does the level of firearm ownership and stringency of restrictions correlate with crime rates across different states in the United States, and what differences can be observed between states with stricter vs. more lenient gun laws?"

II. DATA SOURCES

This report utilizes three primary datasets: *FBI NICS Firearm Background Checks*, *Firearm Mortality by State* and *FBI Crime Data*. These comprehensive datasets provide valuable information on firearm ownership granted permits, crime statistics, and firearm mortality rates at the state level. The analysis focuses on six U.S. states, representing two distinct regulatory approaches to firearm ownership. California, Massachusetts, and New York are examined as states with strict regulations, while Texas, Alaska, and Wyoming are analysed as states with lenient policies.

Given that the raw data are obtained from official organizations, an Extract, Transform, Load (ETL) pipeline is implemented to ensure data quality and facilitate thorough analysis. The ETL process refines the datasets through key steps: filtering data to the six states of interest, removing irrelevant columns, performing data type conversions, and grouping and summarizing data for state-

level insights. The cleaned datasets are then saved as CSV files and loaded into an SQL database.

A. Data Structure

FBI NICS Firearm Background Checks represents a key component in determining the strictness of firearm-related regulations across states. It provides data on the number of firearm background checks initiated through the National Instant Criminal Background Check System (NICS), covering the period from 1998 to 2023.

The dataset's structure includes both temporal and categorical features, with "year" capturing the trend over time for each specific "state". Besides, it contains several integral features such as "permit", "handgun", "long_gun", "multiple", and "totals", which represent different types of firearm permissions granted after passing the background check. The "totals" feature accounts for the overall number of successful checks, with return cases and failed permits already deducted.

By examining the variations in different types of firearm permits and the overall totals, it becomes possible to draw insights into the strictness of each state's firearm regulations. (*Fig. 1*)

	year	state	permit	handgun	long_gun	multiple	totals
0	1998	alaska	4.0	1365.0	2555.0	61	3985
1	1998	california	5366.0	28641.0	33438.0	0	67445
2	1998	massachusetts	0.0	321.0	1116.0	6	1443
3	1998	new york	1068.0	1094.0	12513.0	12	14736
4	1998	texas	5324.0	23862.0	52248.0	963	82399
5	1998	wyoming	121.0	970.0	2352.0	43	3486

	YEAR	STATE	RATE	DEATHS
0	2022	AK	22.4	164
1	2022	CA	8.6	3484
2	2022	MA	3.7	263
3	2022	NY	5.3	1044
4	2022	TX	15.3	4630
5	2022	WY	20.4	124

Fig. 1. FBI NICS Firearm Background Checks Dataset (left)
Fig. 2. Firearm Mortality by State Dataset (right)

Firearm Mortality by State and *FBI Crime Data* offers crucial insights into the outcomes associated with firearm ownership, serving as a key factor in establishing cause-outcome relationships in subsequent analyses. *Firearm Mortality by State* presents comprehensive firearm mortality statistics at the state level across the United States, providing annual data on deaths resulting from firearm-related incidents.

The structure of this dataset contains both temporal and categorical features. The "year" variable captures trends over time for each specific "state", allowing for longitudinal analysis. Besides, the dataset includes

continuous features such as "rate" and "death", which respectively represent the proportion of firearm-related deaths relative to the state's population and the actual number of death cases. (*Fig. 2*)

	year	state_abbr	state_name	population	violent_crime	homicide	aggravated_assault	property_crime	totals
0	1979	AK	alaska	406000	1994	54	1203	23193	26444
1	1979	CA	california	22696000	184087	2952	93129	1511021	1791189
2	1979	MA	massachusetts	5769000	30650	212	17286	310756	358904
3	1979	NY	new york	17649000	161906	2092	60949	933234	1158181
4	1979	TX	texas	13385000	67988	2235	34043	725109	829375
5	1979	WY	wyoming	450000	1579	41	1224	20129	22973

Fig. 3. FBI Crime Dataset

Similar to the above datasets for "year", "state_abbr" and "state name", the structure of *FBI Crime Data* also includes integral features, covering population of the state, firarm-related crimes ("violent_crime", "homicide", "aggravated_assault", "property_crime") and the total crimes ("totals"). (*Fig. 3*)

The structure of the FBI Crime Data dataset shares similarities with the previously mentioned datasets, incorporating temporal and geographical features. However, this dataset extends its scope to include a range of integral features that contains the population of each state and firearm-related crime categories.

Therefore, the three datasets collectively provide a comprehensive foundation for analyzing cause-outcome relationships in firearm regulation and its impacts. After aggregating the data, it is evident that higher numbers of permits generally indicate lenient states, while lower numbers typically represent states with stricter regulations. (*Fig. 4*)

	year	state	population	permit_totals	permit_per_1k	crimes_totals	crimes_per_1k	mortality_rate
0	2014	alaska	737046	87623	118.884032	28302	38.399232	19.2
1	2014	california	38792291	1474616	38.013120	1194460	30.791169	7.4
2	2014	massachusetts	6755124	179344	26.549328	170580	25.251942	3.2
3	2014	new york	19748858	365427	18.503703	460996	23.342919	4.2
4	2014	texas	26979078	1465992	54.338106	990280	36.705480	10.7
5	2014	wyoming	584304	63063	107.928407	13534	23.162600	16.2

Fig. 4. Combined Dataset

B. Licenses

All datasets used in this analysis are obtained from official organizations, ensuring their reliability and authenticity. The *Firearm Mortality by State* is licensed under Section 308(d) of the Public Health Service Act and CIPSEA. The *FBI NICS Firearm Background Checks* and *FBI Crime Data* are licensed under MIT License and accessible through the FBI's FOIA Library respectively. Data is used for transparency, academic research and statistical purposes only.

III. DATA ANALYSIS

Following the data analysis process, the report focuses on the characteristics of each state and firearm-related crimes.(*Fig. 5*) The data analysis employs Correlation Analysis and Exploratory Analysis, the following insights obtained:
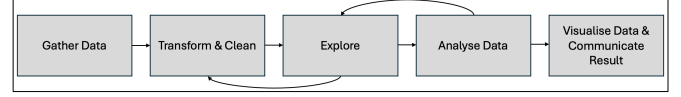

Fig. 5. Data Analysis Process

A. Correlation Analysis

Correlation Analysis is a statistical method used to discover relationships between variables and how strong that relationship is. In this case, it explores the correlation between firearm ownership permit grants, firearm-related mortality rates, and crimes.

Firearm permit vs. Firearm-Related Crimes/ Mortality Rate

Methodology: Pairplot is used for correlation analysis. Key metrics and features are extracted, including firearm permits granted after background checks ("permit_totals"), and firearm-related crimes ("crimes_totals" and "mortality_rate"). The goal is to determine if firearm background checks significantly impact firearm-related crimes and mortality rates and observe the feature correlations for each state individually.

Interpretation: As shown in Figure 6, it shows that Massachusetts, California, New York, and Texas generally offer fewer firearm permits, which correlates with lower mortality rates. Conversely, Wyoming and Alaska, which grant more permits, show higher mortality rates.

The relationship between permits and firearm-related crimes is less straightforward. Generally, states with higher firearm permits (Alaska and Texas) show higher crime rates. However, there are exceptions: Wyoming, despite granting the most permits, has a crime rate similar to New York and Massachusetts, which issue fewer permits.
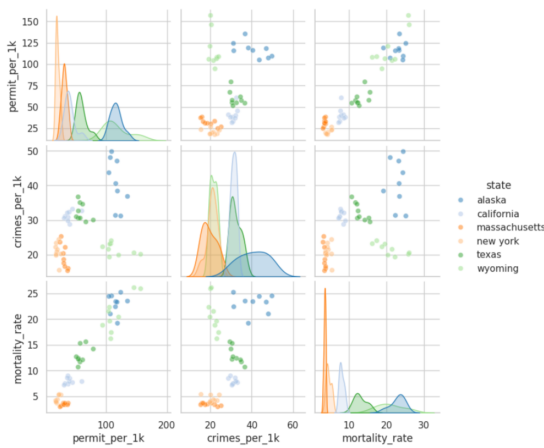
Fig. 6. Pairplot of four key features for six specific states

Results: Lenient states (Wyoming, Alaska, and Texas) with less restrictive regulations and higher firearm permit issuance show a significantly stronger correlation with higher mortality rates compared to strict states (Massachusetts, California, New York).

Firearm-related crimes generally follow a similar pattern, though less pronounced. Strict states like Massachusetts and New York, where obtaining firearm permits is more challenging (lower permit rate), correlate with lower crime rates compared to other states.

This suggests that stricter gun regulations may contribute to reduced firearm-related crimes and mortality, while more lenient policies are associated with higher risks, particularly in terms of firearm-related deaths.

B. Exploratory Analysis

Correlation analysis provides initial insights into associations between firearm permits, crimes, and mortality, but it does not imply causation. In the following, Exploratory Analysis is employed to identify patterns, trends, and characteristics for each state.

Firearm Permit Granted vs. Firearm-related Crimes

Methodology: FacetGrid is used to create individual line chart and subplots for each state, allowing for easy comparison. Each subplot displays line charts showing the proportion of firearm permits and firearm-related crimes per 1,000 citizens. This approach accounts for geographical factors by

presenting data proportionally. Blue lines represent permits, while orange lines represent crimes.

Interpretation: Generally, Alaska, Wyoming, and Texas show higher firearm permit issuance rates, with Alaska and Wyoming exceeding 100 permits per 1,000 citizens. In contrast, strict states (California, Massachusetts, and New York) have lower permit rates, ranging from 20 to 40 per 1,000 citizens.

On the other hand, Alaska, California, and Texas have higher crime rates (30-40 per 1,000 citizens), while other states show lower crime rates (15-25 per 1,000 citizens).

California, Massachusetts, and New York reveal considerable variation. Massachusetts shows a negative correlation between permits and crimes. As permit numbers increase in Massachusetts, crimes continuously decrease. Interestingly, California's significant permit drop (60 to 35) between 2016-2018 had little impact on crime rates. New York's permit decrease (26 to 24) after 2020 initially corresponded with a crime rate drop (20 to 16), but crimes then increased sharply to 24 per 1,000 in 2022. *(Fig 7)*
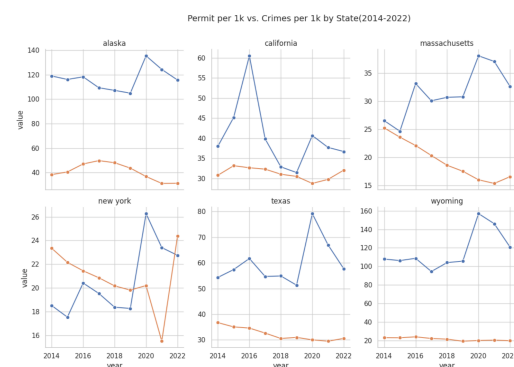

Fig. 7. Firearm Related Mortality Rate Across 6 States

Results: Lenient states (Alaska and Texas) generally have higher firearm-related crime rates despite higher permit numbers, suggesting easier access to permits may increase crime potential. Strict states typically have lower crime and permit rates. However, the relationship between permits and crimes is not consistently direct across all states. Strict states like Massachusetts and New York show fluctuations where permit numbers do not always directly reflect crime rates.

Firearm Permit Granted vs. Mortality Rate

Methodology: Two line charts are used to visualize Firearm Permits Granted and Mortality Rate over time. The data preparation involved several steps to merge and combine key features effectively.

Firstly, while the mortality rate data spans from 2014 to 2022, other datasets cover periods from 1979 to 2022 or 1998 to 2023. To ensure consistency and accuracy in the analysis, only data from 2014 to 2022 was included.

Besides, since the mortality rate was obtained directly from the primary dataset, the population data was sourced from the FBI Crime Data. To align the values for meaningful comparison, the proportion of firearm permits was calculated by dividing the total number of permits by the population and then multiplying by 1,000. This conversion provides the number of firearm permits granted per 1,000 citizens, facilitating a standardized analysis across different states.

Interpretation: The line charts reveal the following order of states for firearm permits per 1,000 citizens from highest to lowest: Wyoming, Alaska, Texas, California, Massachusetts, and New York. (*Fig. 8*)

For mortality rates, the order is similar: Wyoming, Alaska, Texas, California, New York, and Massachusetts, with only New York and Massachusetts swapping positions. (*Fig. 9*) The contrast in mortality rates is particularly stark. Alaska and Wyoming show exceptionally high rates, ranging from 15 to 25 firearm-related deaths per 1,000 citizens. This is significantly higher than the states with stricter regulations, where the mortality rate is less than 5 per 1,000 citizens.

Results: Lenient states (Wyoming, Alaska, and Texas) show higher numbers of firearm permits granted, likely due to less restrictive regulations making it easier for citizens to obtain permits. Correspondingly, these states also exhibit comparatively higher mortality rates related to firearms. This pattern suggests a potential link between easier access to firearms and increased firearm-related deaths.
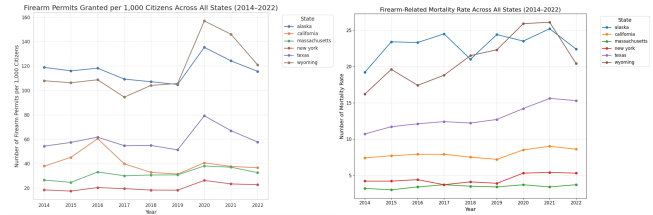

Fig. 8. Firearm Permits Granted per 1,000 Citizens Across 6 States
Fig. 9. Firearm Related Mortality Rate Across 6 States

IV.   CONCLUSION

A. Summary

Our analysis reveals significant differences between states with strict and lenient firearm regulations. Strict states like California, Massachusetts, and New York demonstrate more restrictive regulations that lead to lower firearm-related crime rates. In these states, citizens undergo rigorous background checks and must demonstrate comprehensive knowledge to obtain firearm permits, resulting in generally lower proportions of permits issued and correspondingly lower crime rates.

Conversely, lenient states such as Wyoming, Alaska, and Texas show a strong correlation between less restrictive regulations and higher firearm-related mortality rates. These states have a larger proportion of citizens with firearm permits, and the easier access to permits potentially contributes to higher firearm-related death rates.

B. Limitation and Future Work

While clear correlations were found in lenient states, the impact of permit numbers on crime rates in strict states was less significant. Our current analysis, while informative, is limited in scope and does not account for various factors such as economic development, education levels, cultural harmony and so on.

In the future of work, we should incorporate additional factors to provide a more comprehensive understanding of the relationship between firearm regulations, ownership, and public safety outcomes across different states. By expanding the analytical framework, we can develop more insights into the patterns of gun ownership and its societal impacts.