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. 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 and assess how regulation differences impact crime rates, 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 [1], Firearm Mortality by State [2], and FBI Crime Data [3]. 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 more 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 involves several key steps to refine the datasets. These include filtering data to the six specific states of interest, removing irrelevant columns, performing data type conversions for consistency and grouping and summarizing the data to provide meaningful insights at the state level. Finally, the data are grouped and summarized to provide meaningful insights at the state level. Finally, the cleaned datasets are saved in two formats: as CSV files for easy access and loaded into an SQL database to support more complex queries and future analysis.

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 [2] and *FBI Crime Data* [3] 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 [2] 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* [3] 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 ("year", "state_abbr","state name"). 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(“violent_crime”, “homicide”, “aggravated_assault”, “property_crime”).

Therefore, the three datasets collectively provide a comprehensive foundation for analyzing the cause-outcome relationships. They cover key aspects ranging from state-specific characteristics, Firearm Background Checks, and population data to firearm-related crimes and mortality rates. By integrating these diverse datasets, the analysis can explore the correlation and understanding between gun laws, ownership patterns, and public safety outcomes.

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. Appropriate credit and link to the license will be provided.

III. DATA ANALYSIS

After aggregating and exploring the data [4], the report primarily focuses on the characteristics of each state and firearm-related crimes. The data analysis employs Correlation Analysis and Exploratory Analysis, the following insights obtained:

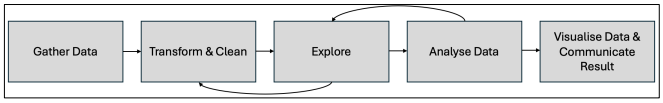

Fig. 4. Data Analysis Process

A. Correlation Analysis

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

Methodology: A heatmap and pairplot are used for correlation analysis. Key metrics and features are extracted, including state population ("population"), firearm permits granted after background checks ("permit_totals"), and firearm-related crimes ("crimes_totals" and "mortality_rate"). This analysis aims to determine if firearm background checks ("permit_totals") play a key role in reducing firearm-related crimes and mortality rates. The pairplot allows for observation of feature correlations for each state individually.

Interpretation: The heatmap reveals a negative correlation (-0.25) between firearm permits granted and mortality rate, suggesting that more permits granted in a state correlate with fewer gun-related deaths. However, there is a strong positive

relationship (0.93) between firearm permits granted and crimes, indicating that more permits potentially lead to increased crime rates. (*Fig. 4*)

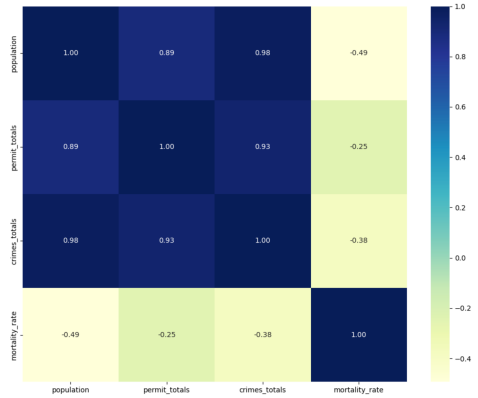

Fig. 4. Heatmap of four key features

A deeper analysis using the pairplot 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. Interestingly, the correlation between permits and firearm-related crimes is less clear. For instance, Wyoming, which grants the most permits, has a similar crime rate to New York and Massachusetts, which grant fewer permits. (*Fig. 5*)

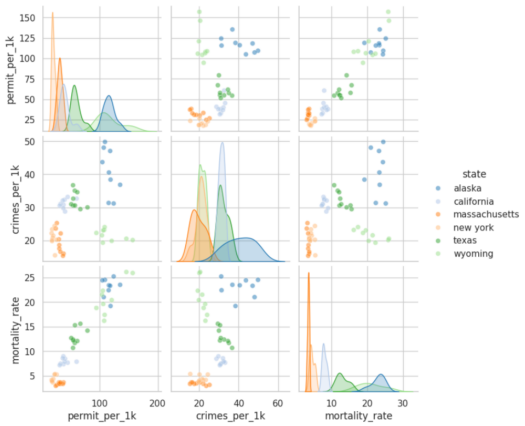

Fig. 5. Pairplot of four key features for six specific states

In General: Firearm permit vs. Firearm-Related Crimes/ Mortality Rate

Results: To some extent, granting more firearm permits appears to reduce firearm-related deaths, especially for Wyoming and Alaska (lenient states). However, in general, allowing more people to own guns potentially increases overall crime rates in society. What's more, the relationship between permits and crime rates varies by state. For instance, Wyoming, despite having a higher number of permits granted, shows crime rates similar to states with lower permit numbers.

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. 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. 6*) The contrast is stark, with Wyoming and Alaska showing exceptionally high rates - over 100, or even 120 permits per 1,000 citizens. This is

significantly higher than the least permissive states, which only issue 20 to 30 permits per 1,000 citizens.

For mortality rates, the order is similar: Wyoming, Alaska, Texas, California, New York, and Massachusetts, with only New York and Massachusetts swapping positions. (*Fig. 7*)

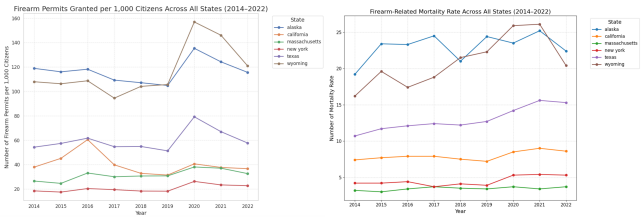

Fig. 6. Firearm Permits Granted per 1,000 Citizens Across 6 States
Fig. 7. Firearm Related Mortality Rate Across 6 States

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.

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, firearm-related crime rates show a slight decrease over time, with an exception from 2021 to 2022. Alaska, California, and Texas exhibit higher crime rates, ranging from 30 to 40 per 1,000 citizens. Despite significant increases in permits granted from 2021 to 2022, crime rates remain relatively stable in these states. Other states show crime rates between 15 to 25 per 1,000 citizens.

California, Massachusetts, and New York display considerable variation. Massachusetts, in particular, demonstrates a significant negative relationship between permits and crimes. As permit numbers increase in Massachusetts, crimes continuously decrease. *(Fig. 8)*

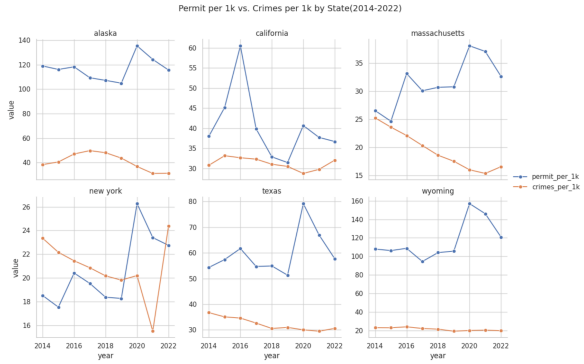

Fig. 7. Firearm Related Mortality Rate Across 6 States

Results: Comparatively, lenient states (Alaska and Texas) have higher firearm-related crime rates, despite also having higher numbers of permits granted. Although strict states (Massachusetts and New York) show fluctuations, their crime rates are generally lower than those of lenient states.

IV. CONCLUSION

A. Summary

Our analysis shows a positive relationship that strict states, which have more restrictive regulations, lead to lower firearm-related crime rates. In these states, citizens undergo more rigorous background checks and are required to demonstrate comprehensive knowledge to obtain firearm permits. Therefore, the proportion of these states generally have lower permits and crime rates.

Furthermore, our analysis demonstrates a strong relationship between lenient states (Wyoming, Alaska, and Texas) and higher mortality rates due to firearms. These states, characterized by less restrictive regulations, show a larger proportion of citizens with firearm permits compared to strict

states. This easier access to permits potentially contributes to higher firearm-related death rates.

B. Limitation and Future Work

Exploring the firearm-related crimes, especially in different states, involves various factors, such as economic development, education levels, cultural harmony and so on. Our current analysis, while informative, is limited in its scope. Therefore, in the future of work, additional factors will be applied, in order to provide a more comprehensive understanding of the relationship between firearm regulations, ownership, and public safety outcomes across different states.