

Visual Analysis of Gun Violence in the United States

Tianhao Wang Hang Chen Lynn Li Jingrui Gan Yu Yan
 jeffwth@umich.edu hangchen@umich.edu qilinli@umich.edu jingrui@umich.edu kuminia@umich.edu

Abstract: Gun violence has always been a complex and pervasive problem in the US, with devastating consequences for individuals and communities. The recent indiscriminate shooting at Michigan State University has brought the issue to wider attention, especially from nearby residents. Despite numerous efforts to address this issue, gun-related deaths and injuries continue to occur at alarming rates across the country. In this paper, we visualize some of the details of the gun violence problem in the US and some possible factors behind this, using data-driven approaches to shed light on this critical issue. Our goal is to let the general audience know about the current situation of gun violence in the United States, including the summary in time and space dimension, as well as the analysis of some possible factors.

Our final visualization on Tableau Public:
[https://public.tableau.com/app/profile/qilin.li5994/viz/Finalproject5/FinalDashboard - 2.](https://public.tableau.com/app/profile/qilin.li5994/viz/Finalproject5/FinalDashboard-2)

stronger gun control measures and those defending the Second Amendment right to bear arms.

Thus, it is crucial to let more ordinary residents know the current situation of shooting in the United States, explore the underlying trends and analyze the possible factors behind the phenomenon.

In this project, we collect different kinds of data of gun violence in various aspects like temporal and spatial dimensions of all states in the US. With these datasets, we construct a comprehensive visualization set to display the current situation and change of gun violence at multiple angles. Secondly, we find some other datasets about some social attributes in the states of the US, such as economic situation and citizen's level of education which may have influence on gun violence in the US. Based on these datasets, we display those social factors and study their effect on the phenomenon. Our final work could serve as a tool to educate the general public and residents about gun violence.

II. RELATED WORK

I. INTRODUCTION

Citizen gun control is always a controversial topic and gun violence has always been a significant issue in the United States. The country experienced a high rate of firearm-related incidents, including mass shootings, homicides, suicides, and accidents. During the COVID-19 pandemic, gun violence increased in many parts of the United States. This increase was attributed to various factors, such as economic stress, social unrest, and increased firearm sales.

Efforts to address gun violence in the US had been ongoing, with calls for stricter gun control legislation, improved mental health services, and community-based intervention programs. However, the issue remained divisive, with opinions split between those advocating for

A. Gun Violence Archive

The Gun Violence Archive (GVA) [1] is an online resource that compiles data on gun violence incidents in the United States, aiming to provide a comprehensive, unbiased, and accessible repository of information. The website is designed for researchers, policymakers, journalists, and the general public, offering valuable insights into the multifaceted issue of gun violence in the country. GVA offers various kinds of information: incident reports, summary statistics, interactive maps, methodology and analysis of gun violence. The GVA serves as a valuable resource for those interested in understanding and addressing the issue of gun violence in the United States. By offering comprehensive, near real-time data, the GVA aims to inform evidence-based

decision-making and foster public awareness of this critical public health and safety issue.

There are many research and papers on gun violence issues based on datasets from GVA. By analyzing 25 firearm laws and studying datasets from GVA, the work [2] led by Kalesan examined the impact of various state-specific firearm laws on firearm mortality rates across the United States.

The study [3] done by Reeping found that states with more permissive gun laws and higher gun ownership rates experienced a significantly higher number of mass shootings. It suggests a growing divide between permissive and restrictive states, with more restrictive states experiencing fewer mass shootings.

B. Everytown for Gun Safety · Support Fund

Like GVA, Everytown [4] is also a non-profit organization focused on reducing gun violence in the US by promoting gun safety policies, raising awareness, and conducting research, which has a similar goal to this project. It consists of several parts: Everytown Research & Policy, Moms Demand Action for Gun Sense and Mayors Against Illegal Guns. Their goal is to create safer communities by preventing gun violence and advocating for sensible gun laws and regulations.

There are also some papers based on this website. Conner [5] led a work which explored public opinion on the connection between household firearms and suicide risk and found that only 15.4% of adults agreed that the presence of a firearm increases suicide risk, with even lower agreement among firearm owners.

The study done by Kagawa [6] investigated the effect of repealing comprehensive background check laws on firearm homicide and suicide rates in Indiana and Tennessee. The results showed there is no association between changes in firearm homicide and suicide rates and the repeal of these laws.

III. LEARNING OBJECTIVES

The learning objectives of this project are to educate the general audience about gun violence in the United States, including the current situation and underlying trends, as well as to analyze the possible factors behind this phenomenon. By applying different kinds of data-driven visualizations and analysis, learners should be able to get a comprehensive impression on gun violence

issues and provide some informed decisions about gun control and community-based intervention after learning about the potential factors.

IV. DATA

Our US gun violence data primarily comes from the "Gun Violence Archive" website and Kaggle. Data related to mandatory gun ownership rates, poverty rates, and the proportion of people with mental health issues come from relevant articles and official websites in their respective fields.

When processing the data, we ensured that the data was sufficiently new and had a large enough sample size. We also attempted to standardize the data's time periods as much as possible to ensure that our visualization results were more scientific and persuasive. We used Python several times to group and integrate the data sets, so that we could achieve perfect interaction with our data.

V. IMPLEMENTATION

A. Trend over the years

For the overall gun violence across the US, we tried different visualization methods. At first, we used the US map with circles to encode the number of gun incidents in the area (Figure 1). But this method cannot provide many insights for the audience, especially showing the trend throughout the time.

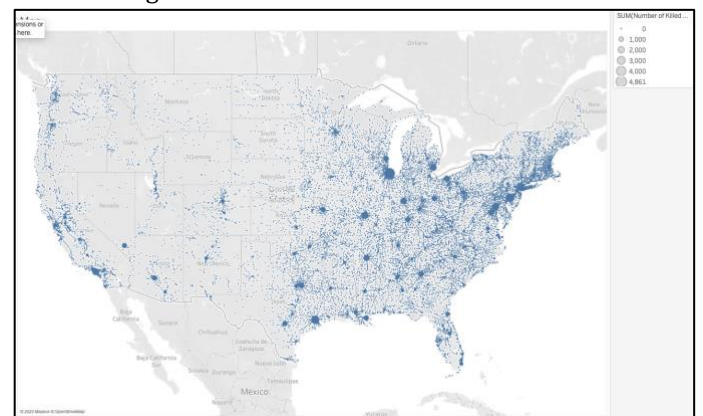


Figure 1

Therefore, we decided to use small multiples to visualize the trend in different states in recent years,

which could provide insight into the trend in each state and comparison between each.

As small multiple is not a general form of visualization in Tableau, we followed the tutorial from the article in the Tableau community, “How to create a small-multiple tile map” (<https://www.tableau.com/blog/how-create-small-multiple-tile-map-54303>).

First, we used the line chart to encode the killed people and area to encode the number of incidents in each state. The year is the x-axis. Then we connected the data with the template data source using the State code. Lastly, we changed the tooltips and labels to make the important information be visualized.

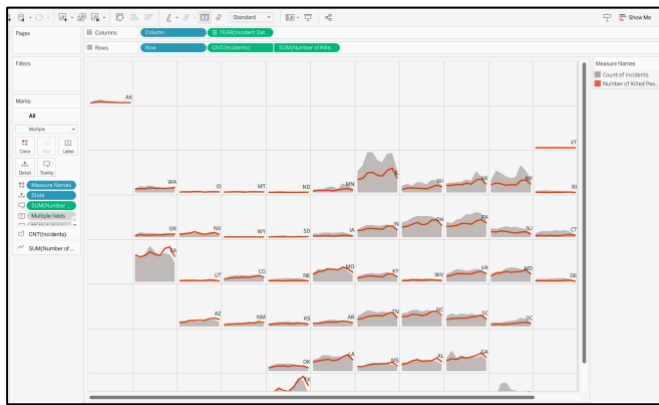


Figure 2

B. Gun support & Ownership

The access to guns drastically affected the escalation and lethality of the conflict [9]. Thus, we are interested in visualizing gun ownership for different states, together with how people’s attitudes toward gun ownership changed overtime.

Visualizing gun ownership by states is rather straightforward. First, we read the data with Pandas and performed elementary data exploration and cleaning (checking data types, null values, etc.). Then, we realized that to connect and interact with the small multiple chart and other factors in Tableau, information of state abbreviation is needed, which was solved by adding a new column of state code through a pre-defined dictionary. Later, we loaded the cleaned data into Tableau and sorted the gun ownership data by states in descending order. At the end, we adjusted the format of tooltip, axis unit, color pallet, and title to ensure consistency throughout the dashboard. Now, the ownership chart is ready for further interaction implementations.

For attitudes toward gun support, the data itself is time-series in nature and does not need extensive cleaning. We started by merging three different gun support attitudes into one chart with a shared y axis. Then, we chose different hues but succinct legend aliases for different attitudes, which set the basic configuration of the gun attitudes graph. To add more interactions and compare between attitudes conveniently, we decided to add a vertical, cursor-tracking reference line. Thus, we first created a new variable based on the timestamp called “line”. Then we configured such a “line” parameter as the input in the reference line operation, oriented vertically upon the x axis. Lastly, we defined a “change parameter” action on the final dashboard and binded the “line” parameter with the x axis in a hovering manner.

C. Poverty

For the implementation of the poverty visualization, we tried many different types of visualization methods. At first, we only considered listing the states with the highest poverty rates and marking the name of the state, the count of incidents, the number of injured and killed people caused by gun violence, and the poverty percentage in tooltips. However, this visualization was not very intuitive and did not reflect the situation of each state and the corresponding parameters very well. It was very unsatisfactory if we only display them through tooltips.

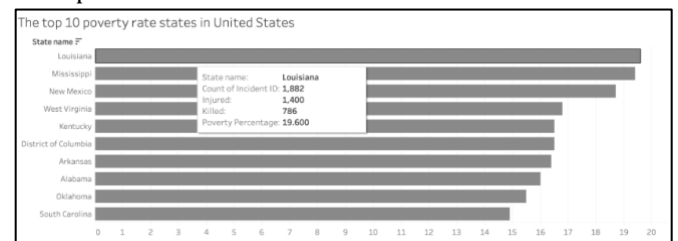


Figure 3

In addition, we are also concerned about the changes in the poverty rate in recent years. But this single line is too simple, and it is difficult to obtain useful information from it. As a component of visualization, it is very unqualified.

So, we started thinking about whether there is a more reasonable way to visualize poverty, while displaying the close connection between gun violence and poverty rate without losing key information. We first selected the poverty rate for each state in 2021 and found the corresponding number of injured and killed people caused by gun violence for that year. It was very difficult

D. Mental health

to show so many dimensions of information at the same time, and a series of visualizations such as line charts, bar charts, and pie charts were difficult to generate. Therefore, a scatter plot naturally became my choice. The size, coordinate, and even color of the points in the scatter plot can be used to express information, which is in line with the multi-dimensional information visualization we want to design. So we used poverty percentage as the x-axis, and count of gun violence incidents as the y-axis, to express the connection between poverty and the occurrence of gun violence from the perspective of the coordinates. Then, we used the size and color of the scatter plot to express the number of people injured and killed by gun violence respectively. When the scatter plot is larger, the number of people injured by gun violence is also higher. When the color of the scatter plot is closer to red, the number of people killed by gun violence is higher. Finally, I designed the following visualization work.

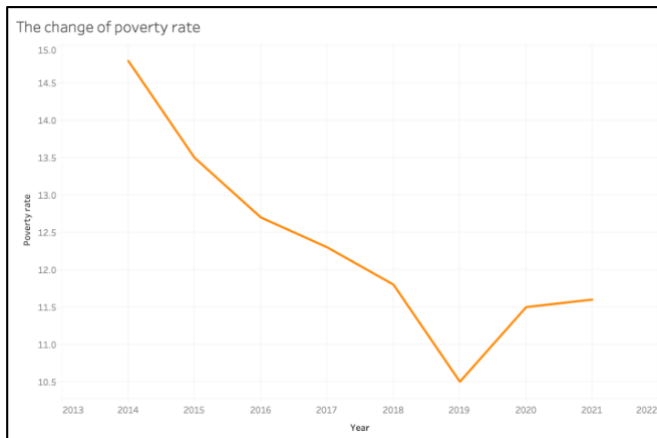


Figure 4

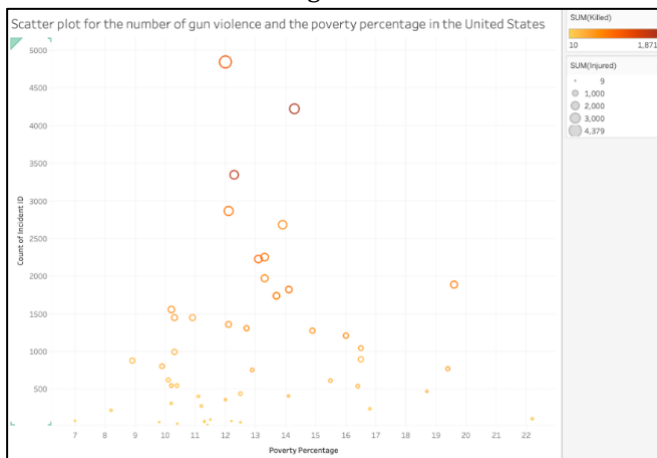


Figure 5

Through obtaining statistical data on mental health in the United States, we have tried various methods of visualization. The first method we thought of was the basic bar plot. We sorted the number of people with mental illness by state in the United States in 2021 and obtained a bar plot. In the bar plot, the y-axis represents each state, and the x-axis represents the percentage of people with mental illness in each state. We found that Virginia has a high percentage of people with mental illness, up to 5.53%, from the bar plot. However, with 50 states in total, it is difficult to display the data of all 50 states concisely in a bar plot, and the information that a bar plot can convey is limited.

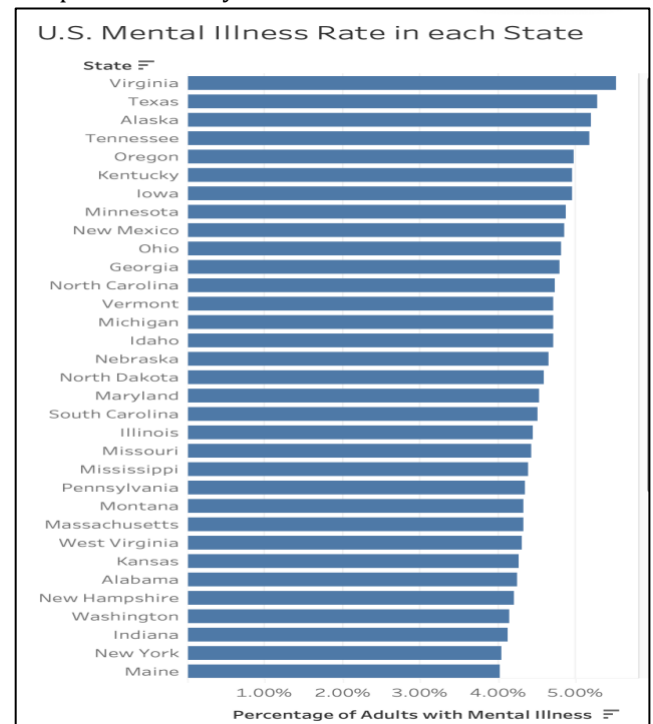


Figure 6

We also tried to use scatter plots to compare the data. In the scatter plot, each point represents a different state, and the x-axis represents the growth rate of people with mental illness, while the y-axis represents the total number of people with mental illness. Different colors represent the percentage of people with mental illness, with darker colors indicating higher percentages. From this scatter plot, we found that California has far more people with mental illness than other states, although its percentage of people with mental illness is not the highest. This also indirectly reflects the shortcomings of the bar plot. With a scatter plot, we cannot see the relationship between the growth rate of people with

mental illness and the total number of people with mental illness in each state in the graph, as it is difficult to express the functional relationship between variables through the distribution of each scatter point and the regression line. In addition, since the dataset lacks data on gun violence, it is difficult to address the issue solely through mental health data.

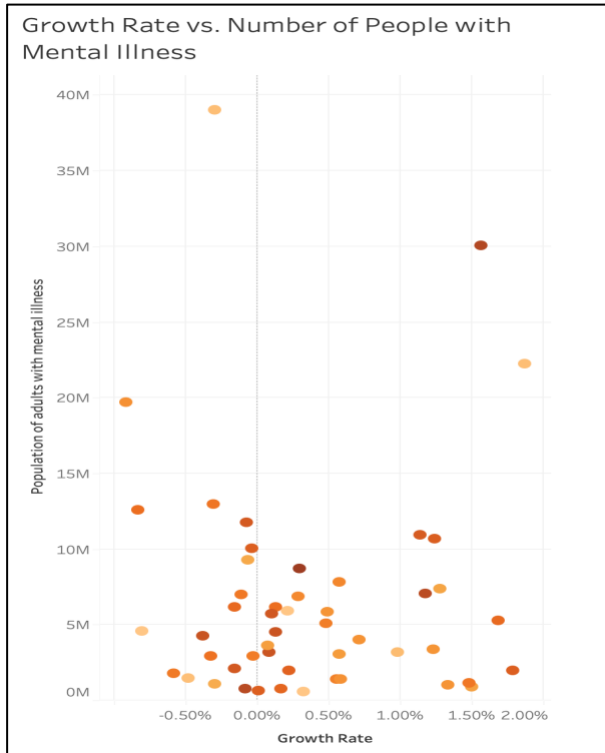


Figure 7

Therefore, we have come up with a better solution to address this issue. First, we merged the gun violence data and mental health data using pandas to process the data. This enables us to better analyze the relationship between the two by incorporating gun violence data into the visualization. Additionally, we abandoned the use of scatter plots and bar plots for visualization and opted for a map format. This not only adds more visual elements to our visualization dashboard, but also allows us to add gun violence-related data, such as death toll and injury numbers, through tooltips.

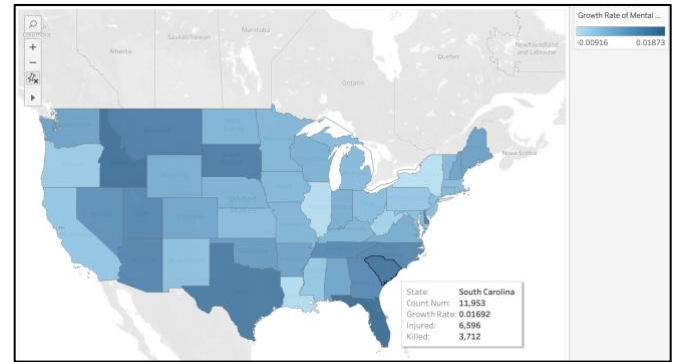


Figure 8

E. Dashboard Interaction

In this visualization, we have two actions, which are presented in the form of hover and select.

| Show actions for | | | |
|--|----------------------------------|-------------------------|--------|
| <input checked="" type="radio"/> This workbook | <input type="radio"/> This sheet | | |
| Name | Run On | Source | Fields |
| Parameter1 | Hover | Final Dashboard (Gun... | line |
| Highlight1 | Select | Final Dashboard | All |

Figure 9

Specifically, the hover interaction is targeted at the gun support facet. When we hover over the gun support plot with the mouse, a line appears to show the corresponding coordinate on the x-axis, and tooltip information is displayed.

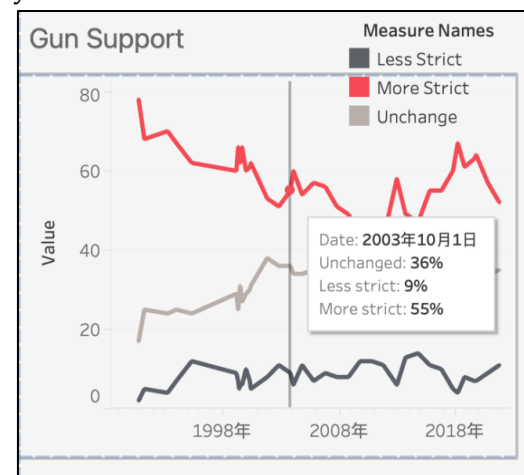


Figure 10

In the highlight form of interaction, we associate all data containing state information in the facets. By selecting a state using the mouse, all facets containing information about that state will highlight the corresponding content. The results are shown in the following figure. After

selecting Alabama state in Gun ownership, our main map, Poverty, and Mental health facets all highlight their corresponding content. In addition, selecting a state in the main map, Poverty, or Mental health facets will also have the same effect.

VI. RESULTS

A. Trend over the years

For the trending over the years, there's a graph showing the number of incidents and killed people from 2014 to 2022 in the US. Below, it shows the trend in different states. When the user hovers on the graph, the tooltip will show the exact number of killed people and incidents in that year.

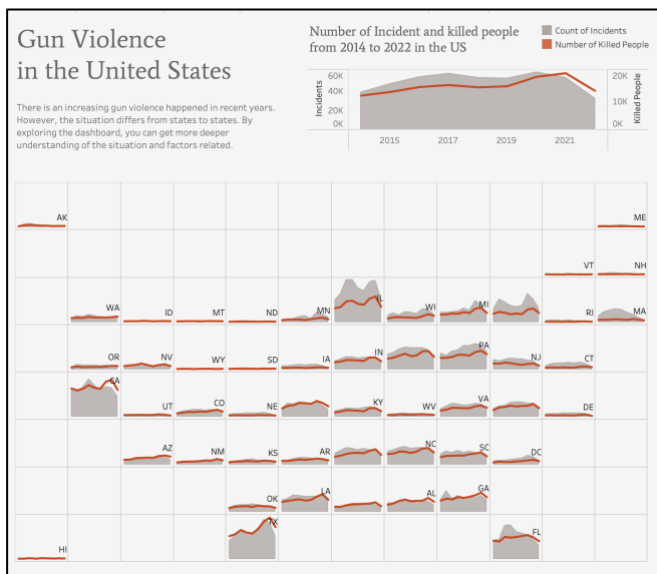


Figure 11

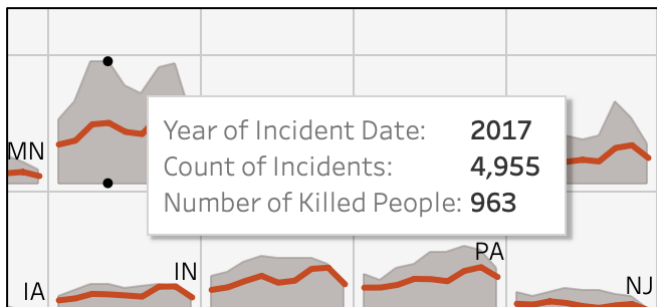


Figure 12

B. Gun support & Ownership

For gun ownership in 2023, the top 9 states by percentage ownership are shown in Figure 13. All 9 states have percentages higher than 50%, with Montana having the highest ownership. Also, those states with higher ownership tend to be in the mid US, rather than at east or west coastal areas.

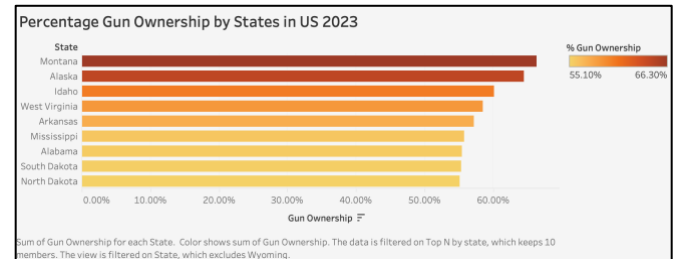


Figure 13

For the line chart of gun support (Figure 14), the attitude of "less strict" remains relatively steady, oscillating around 8% from 1991 to 2021. However, the patterns of "stricter" and "unchanged" are almost mirror images of each other, where the "stricter" attitude kept decreasing from 80% initially to 40% at around 2013, followed by an increase back to 70% at 2018. It is worth mentioning that the percentage of "stricter" started to decrease again after 2018, with a corresponding increase in the "unchanged" and "less strict" attitudes. Those are the hints shows that people's attitudes toward gun are relaxing, which could play a role in increasing gun violence.

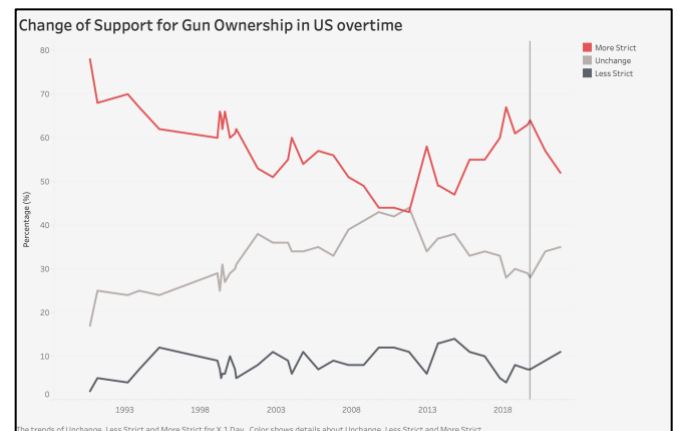


Figure 14

C. Poverty

After organizing the dashboard, the final poverty dashboard is shown in the figure below. As can be seen in this visualization, each scatter plot represents the situation of a state, with poverty percentage and count of incidents represented on the x and y axes, respectively.

In addition, the size of each scatter plot is used to represent the number of people injured by gun violence, while the color represents the number of people killed by gun violence. By clicking on each scatter plot, interactive visualizations related to the state can be displayed in the dashboard and highlighted.

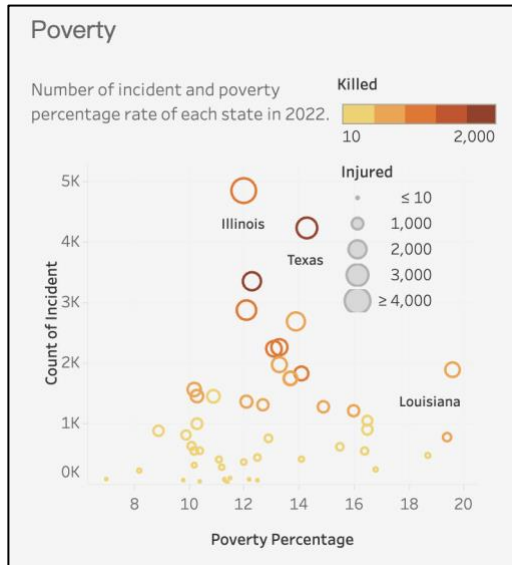


Figure 15

D. Mental health

Through the final formatting and inclusion of interactions, we have created a map of mental health data. From the map, we can easily see which states in the United States have a higher proportion of people with mental health issues, based on the color intensity.

Through the tooltips, we can also learn about gun violence data for each state. By exploring the interactions between the visualizations, we can discover that mental health is not one of the main factors influencing gun violence in the United States. Having a higher proportion of people with mental health issues in a state does not necessarily mean that the state will have more gun violence incidents. It is often assumed that perpetrators of gun violence have mental health issues, but this opinion is not correct.

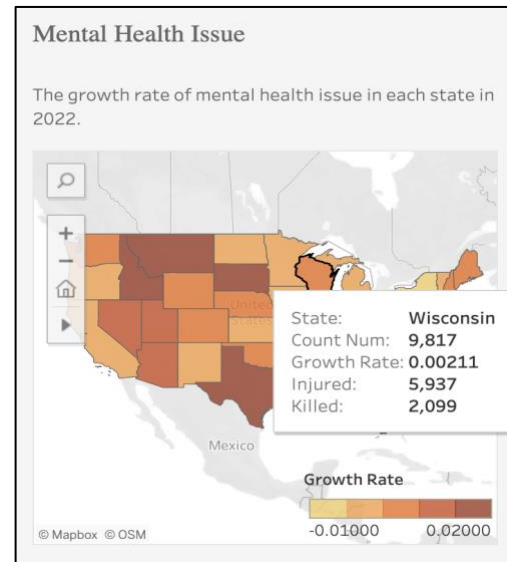


Figure 16

E. Interaction And Overall Display

Here is the result for dashboard interaction:

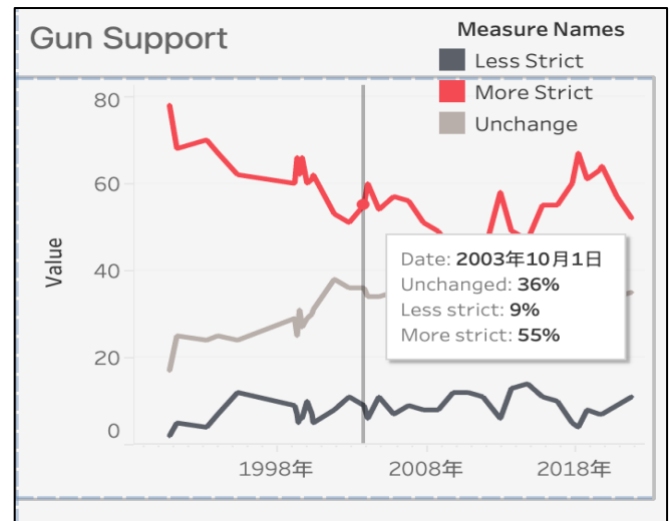


Figure 17

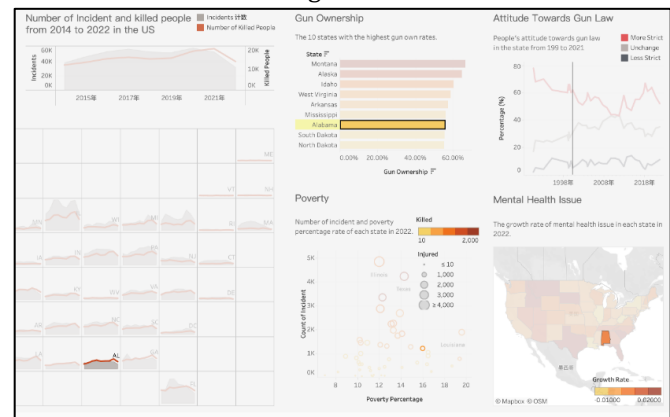
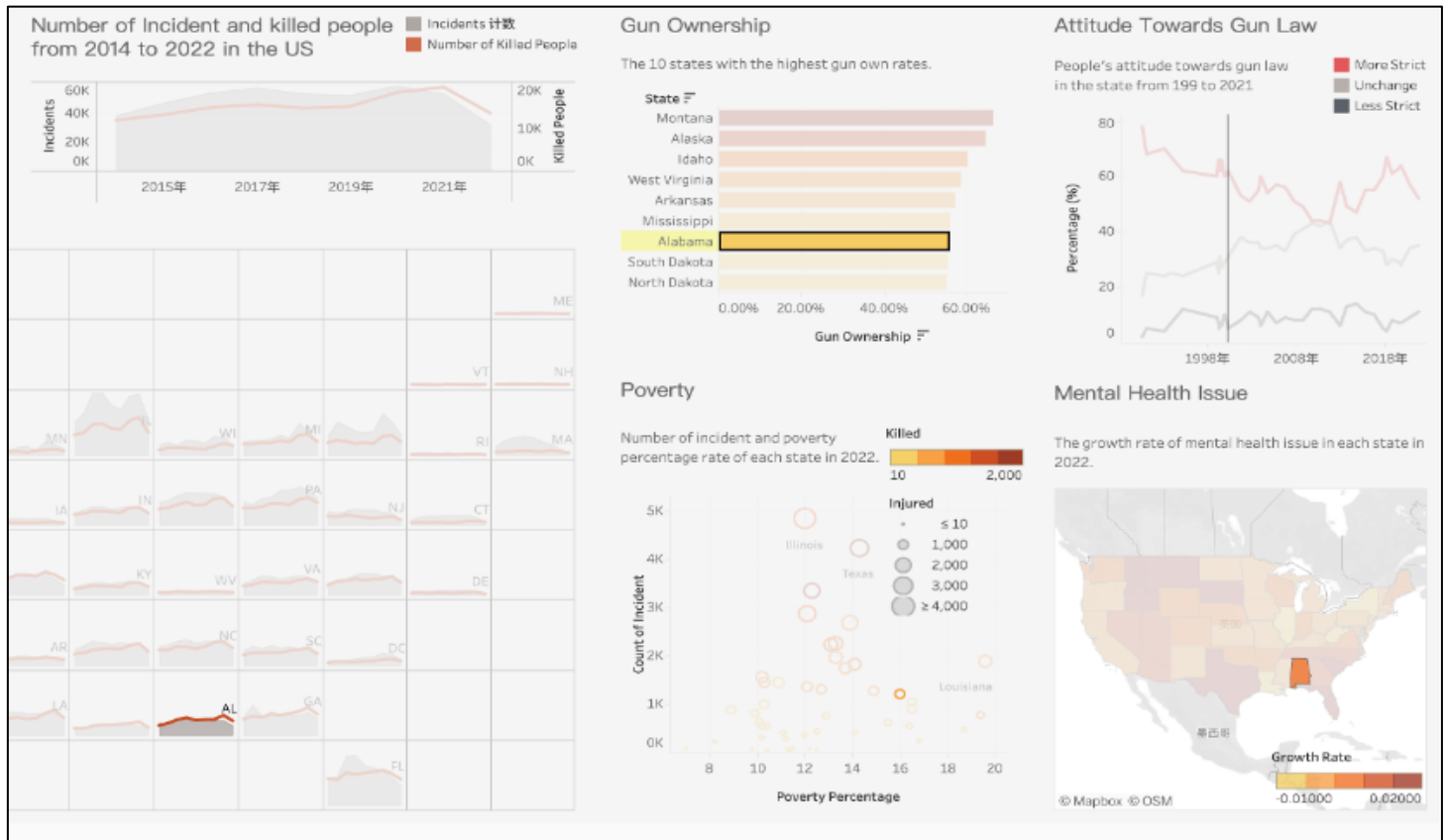


Figure 18



VII. DISCUSSION

A. User Testing and Evaluation

For the evaluation, we aim to help the audience understand the situation of gun violence in the United States. The tasks of our evaluation work mainly focus on how well the audience knows about gun violence changes throughout the time and states and the factors related to the gun violence after seeing the visualization. We invited 5 participants to manipulate the visualization and interviewed them around the user experience and cognitive growth.

Most of the participants expressed their interest in the topic and could understand the theme and topic in each info visualization, which means that our work is suitable for the general audience.

On the other hand, there are also some drawbacks we got from users' feedback. First, the speed of Tableau public is not very satisfactory, especially for rather complex encoding and interaction. Also, the visualization we achieved focused too much on the figures themselves and some graphs are not self-explanatory enough, more words need to be added.

B. Reflection

There are also some reflections throughout our process using Tableau. The tradeoff of using Tableau for encoding should be taken into consideration: we can get quick idea exploration and adaptive design through the highly integrated interface. Also, we can avoid the tedious process of programming work. Meanwhile, there are limited interactions and customization. Due to the lack of immediate numeric information display, we need further exploration after clicking on a state.

VIII. FUTURE WORK

This project is a beginning of the field of gun violence analysis, and there are some possible directions for future deeper work.

First, there is still room for improvement in the study of underlying factors. We have covered three uppermost factors: gun ownership, poverty and mental health. There are some related factors which are worth analyzing, like

citizen income, education level and alcohol addiction. Future work in this direction could also involve collecting additional data on factors like social inequality, mass media situation and immigration, etc. There are some examples of this direction. For instance, the work done by Ali Rowhani-Rahbar [7] quantifies the association between county-level income inequality and firearm homicide rates in the US. It concludes that income inequality was associated with firearm homicide rates among all races/ethnicities, but the association persisted among African Americans even after accounting for contextual determinants of firearm homicide.

Second, it is a valuable direction to examine the impact of different laws and policy approaches related to gun violence in all states. Studies about background checks, assault weapons bans, and red flag laws should be done. The most direct way to assess the impact of state laws and measures is to evaluate how shootings have changed before and after these laws have been implemented. This work is of great research value, because it can enrich our learning objectives by providing guidance and suggestions to state legislators and law enforcers in the formulation and revision of legal measures. There are also some researches in this direction. For example, the research by Siegel [8] analyzed the relationship between gun laws and mass public shootings in the US from 1976-2018, finding that states requiring permits to purchase firearms had a lower incidence of mass public shootings and that states banning large-capacity ammunition magazines experienced fewer fatalities and nonfatal injuries when mass shootings occurred. The drawback is that the types of laws in this research are limited, so the analysis of all types of laws related to guns is necessary.

IX. REFERENCES

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X. APPENDIX

The final visualization on Tableau Public:

<https://public.tableau.com/app/profile/qilin.li5994/viz/FInalproject5/FinalDashboard-2>.

Usability test record:

<https://docs.google.com/document/d/1I9vuGBV10qEpKsmLN--DUOEphudZRMhhzpztX5fzY7Y/edit#heading=h.l9wa1yh6x813>