A BIG DATA PERSPECTIVE ON THE RELATIONSHIP BETWEEN FIREARM LAWS AND MASS SHOOTINGS: DATA VISUALIZATION APPROACH

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Abstract

To examine the relationship between state-level firearm laws and number of mass shooting incidents, we took a data visualization approach. First, a dataset was compiled from multiple sources. Descriptive analysis was represented using a series of data visualizations. We focused on effects of state firearm laws and derived a comprehensive scorecard. Based on the new metric, areas for improvement were identified. Further analysis of a subset of data showed a modest correlation of state-level laws and the number of mass shootings in a state, though not significant. It is a testimony that gun control is a complex issue and firearm laws' effects on mass shooting is not straightforward. The value of data visualization as a research method is shown in a situation of less consensus, such as effects of gun control regulation.

Keywords*: mass shootings, firearm laws, gun control, data visualization*

INTRODUCTION

Gun control is a controversial issue in the United States. Public mass shooting incidents are followed by heated debates over firearm ownership and regulations. Firearm ownership has the potential to make people feel secure in their homes and travel. However, at least some evidence suggests that this perception is inconsistent with outcomes. For example, Dahlberg et al. (2004) and Wintemute (2008) found that the risk of death from homicide is significantly higher for people who live in homes containing guns. In addition to the risks posed to people residing in homes with guns, gun ownership has the potential to pose risks to others. Perhaps the most shocking incidents illustrating this risk are those in which large numbers of people are targeted.

The research question addressed here is whether there is a correlation between state-level firearm laws and mass shooting incidents. To answer this question, we take a data visualization approach to show the pattern, if any, in data. Following the steps of data visualization, we first compiled a dataset from several public sources that will be made publicly available. Second, various data visuals were produced to describe mass shooting issues in US in the last several decades. Third, we developed our own metric, comprehensive scorecard, which is ratings of state firearm laws derived from two such ratings. Then we examined whether the ratings of states are related to mass shooting incidents by state. Conclusions and implications to policy makers can be drawn. This is a case study of using data visualization for decision making and research.

LITERATURE REVIEW

This section provides background information of our study. First mass shooting is defined, and firearm laws are overviewed. Through the lens of crime prevention theories, the effects of firearm laws are discussed. This study takes a data visualization approach. The use of data visualization as a tool for decision-making and scientific research is reviewed.

Mass Shooting Definition

Mass shooting is an area that drew little attention from criminologists until recently (Fox and DeLateur, 2013). One reason for the lack of attention paid to mass shootings is that they were viewed as a special case of criminal homicide with no need for special treatment. A second reason for the lack of research attention is that some believed that the topic fell in the domain of psychiatry since it was believed that mass shootings are often committed by psychopaths. In addition, the incidents of mass shooting were few in number and believed to be highly aberrational. Thus, little research effort has been invested in this area, resulting in limited primary data available for systematic investigation.

The lack of significant research has led to inconsistent data and misunderstandings about the nature and causes of mass shootings, which is counterproductive for having a constructive public conversion on this contentious issue (Fox and DeLateur, 2013).

There is disagreement about the definition of "mass shooting" (Bjelopera et al., 2013). Please refer to Table 1. Because of the definitional issue, there is no official count of the number of mass shootings, which further leads to a disagreement about whether mass shootings are on the rise. Some researchers believe there is indeed an increase in the frequency of mass shooting, especially recently (Blau et al., 2016, Lemieux, 2014). On the other hand, by not excluding cases as the Mother Jones dataset did, Fox and DeLateur (2013) show that there is no increase in mass shootings.

TABLE 1

Definitions of Mass Shooting by Source

Source	Term used by the source	Definition of incident	Incidents excluded from definition
Stanford University Mass Shooting Research (Stanford University Library, 2017)	Mass shooting	A mass shooting incident with three or more causalities	Gang attacks are not included
Federal Bureau of Investigation (Federal Bureau of Investigation, 2013)	Active shooting	"an individual actively engaged in killing or attempting to kill people in a confined and populated area." (page 5)	Gang and drug violence are not included
Gun Violence Archive (Gun Violence Archive, 2017)	Mass shooting	A mass shooting incident with four or more shot and/or killed in a single event, at the same general time and location.	The shooter is not included; gang and drug violence are not included.
Shooting Tracker (Shooting Tracker, 2017)	Mass shooting	An attack that led to four or more causalities excluding Shooter. After merging with Gun Violence Archive in 2016, they have the same definition of mass shooting	
Mother Jones	Mass shooting	Before 2012, it is defined as incident with four or more causalities in a public place (Follman, 2012). After 2012, it revised to be three or more victims died (Follman et al., 2017).	Gang incidents and robberies are excluded

Firearm Laws

Firearm transactions in the United States are governed by federal and state laws. Federal law requires firearm dealers to perform background checks before selling firearms; however, there is some variation in the way in which the law is enforced across states (Cook and Ludwig, 1997). Federal law also requires that firearm dealers keep records of sales, make these records available to law enforcement agents, and track firearms that are lost or stolen from their inventory (Legal Information Institute, Act 922, 2017a). The Firearms Owners' Protection Act

allows unlicensed sellers to make occasional sales of firearms as long as they are not regularly in the firearms business (Legal Information Institute, Act 921, 2017b; U.S. Department of Justice & Bureau of Alcohol, Tobacco and Firearms & U.S. Department of the Treasury, 1999). Private sales are also allowed, and online sales are permitted (Thirdway, 2013). In some cases, private online sellers have sold firearms when buyers told them that they could not pass a background check (Mayors Against Illegal Guns, 2013).

The FBI (Federal Bureau of Investigation, 2017) requires firearm dealers to collect information from prospective buyers about their criminal history, drug usage, and mental health commitments. The FBI checks the records of prospective buyers against federal databases and approves purchases if the prospective buyer is free of serious criminal and mental health problems. Despite these requirements, buyers with criminal and mental health problems in their backgrounds are able to acquire firearms because of variations in background check procedures across the states and venues such as gun shows at which buyers can acquire firearms without going through the background check process.

Several sources evaluate and track the easiness of access to firearms across the states. The two most credible methods were used in this analysis. They are the Gun Law State Scorecard developed by Law Center to Prevent Gun Violence (Law Center to Prevent Gun Violence, 2016) and the Best States for Gun Owners by GUNS & AMMO (Wood, 2015). During the study, it was found that some important indicators were only included in one of the two of these methods. Because of this discrepancy, we developed a third scorecard, which will be introduced in later sections.

Crime Prevention

Criminology research notes that a crime only occurs when several factors come together: a motive, skills and tools, and an opportunity. There are many crime prevention theories and approaches targeting these factors with the aim of reducing the occurrence of crime. A straightforward intervention designed to reduce the mass shootings seems to be the removal of firearms and weapons. Some of the firearm laws are designed to make it harder to acquire the weapons legally by certain groups of individual, such as people with mental illness and criminal backgrounds. Thus, mass shooting may be curbed by such types of laws. One crime prevention perspective involves deterrence which assumes that individuals are rational decision makers. If the consequences of committing a crime are certain and severe one would decide against it for the fear of the consequences since the utility or the gain of criminal behavior is low in comparison (Kennedy. 1983). In this regard, illegal gun ownership may be reduced by harsher punishment. On the other hand, some argue that legally concealed weapons can have deterrence effects on potential crimes.

Another collection of approaches aims at eliminating opportunities. Crime Prevention Through Environmental Design and Defensible Space approaches suggest a set of design principles for environments, mainly physical environments, to eliminate opportunities for crime (Newman, 1966, Ray, 1971). Another similar, but broader, approach is Situational Crime Prevention (Clarke, 1980), which is based on Routine Activity Approach, Rational Choice Perspective, and Crime Pattern Theory (Donkin, 2014). Tactics of Situational Crime Prevention include actions to make committing a crime harder, riskier, less rewarding, or infeasible. These tactics can be applied to the design of public spaces and physical buildings, surveilling practices, hardening of targets, and even inducing guilt or shame. Both Situational Crime Prevention and Crime Prevention Through Environmental Design have components that control the means to commit crime. When the means are tightly controlled or removed, which is what gun control policy attempts, opportunities for crime are reduced.

Gun Control and Mass Shooting

From the above discussion, we can see that firearm laws is central to discussions focused on the prevention of mass shootings. Many laws and regulations have been proposed and implemented. For example, right-to-carry (RTC) laws require a government permit for qualified gun owners so that they can carry concealed weapons in public. There is some evidence that right-to-carry laws have a deterrence effect on potential shooters (Lott and Mustard, 1997; Plassmann et al., 2001). On the other hand, in addition to increased chances for accidental wound and death, such laws make it easier for prospective perpetrators to acquire a weapon. Additionally, studies have found that there is no deterrence effect of RTC laws (Black and Nagin, 1998; Dezhbakhsh, 1998; Duwe et al., 2002; Kovandzic, 2005; Rosengart, 2005). Academic research has shown little conclusive findings on this particular regulation (Aneja et al., 2011). A study of data from 1982 to 2011 on the impact of bans on assault weapons has found that both state and federal bans have significantly negative effects on mass shooting death (Gius, 2015). No relationship is found between gun laws and mass shooting events. However, the type of firearm and mental illness have an impact on the number of victims and fatalities in the US (Blau et al., 2016). After a 1996 massacre, the Australian government, both state and federal, enacted a set of gun laws to ban rapid-fire weapons and to reduce the availability of firearms. Even though there have been no Australian mass firearm killings through May 2016 and a decline in firearm deaths, no conclusion of the effect of these laws on mass shooting can be drawn because during the same period of time, non-firearm deaths also declined greatly (Chapman et al., 2016). Using international, national, and state data, Lemieux (2014) shows that mass shootings and gun ownership rates are highly correlated at the national level. Within the US, at the state level, states with more restrictive gun control laws have lower rates of death by firearm, but do not have fewer mass shootings.

Prior research is not conclusive on the effects of firearm laws on occurrence of mass shooting incidents. Firearm laws are collections of laws and regulations regarding owning and possessing types of firearms. Many firearm laws are at state level, which create different environments state by state. It seems that the effects on curbing mass shooting incidents are not straightforward, especially, coupled with cultural heritage and socioeconomic factors.

Data Visualization

Data visualization uses images to represent data and information in order to help people overcome cognitive limitations. Visualization as a scientific tool has helped in exploration, interpretation, and communication (Tufte, 1983; 1990). Visualization has been recognized as a critical step in scientific exploration and investigation, allowing researchers to see patterns, relationships, and themes in complex data (Johnson et al., 2006). In many disciplines such as medicine, dentistry, computer science, and engineering, data visualization has produced significant advances,

With advances in information technology and computer applications, data visualization has become an integral part of business analytics practice and dashboard design for better business communication and decision-making in organizations (Eppler and Bresciani, 2013; Zhang, 2012). Its effectiveness has been studied in term of improving task performance (Zhu and Watts, 2010), understanding networks (Zhu et al., 2010), and sense-making of data (Baker et al., 2009). Guidelines for visual ontologies are proposed to help design better knowledge management systems (Bera et al., 2011). Researchers have demonstrated the importance of visual decision support in service operations (Sampson, 2012), logistics operations (Chow et al., 2007), supply chain design (Park et al., 2016), risk assessment (Basole and Bellamy, 2014), collaboration (Basole, 2016), and innovation (Basole et al., 2017). Although many visualization studies in business research explore the topics of representing networks, other areas also have benefited from data visualization, such as marketing (Lurie and Mason, 2007), strategy and planning (Eppler and Platts, 2009), and communication patterns (Trier, 2008).

In addition, data visualization's role as a valuable research method has been recognized (Markham, 1998). For example, Chen et al. (2012) visualize the evolution of smart grid technology in a case study to show how such an approach will yield insights of technology development and trend. However, the use of data visualization as a research method has been underutilized in business and management (Basole, 2009). In Basole (2016) and Basole et al. (2017), data visualization is the main methodology. These studies not only illustrate the complementary value of visualization in managerial decision-making but also define a viable data-driven visualization approach in business research.

The effects of firearm laws on mass shooting are complex. This study will examine the relationship between firearm laws and mass shootings via data visualization approach. Are there any interesting patterns of mass shooting at the state level in relation to its firearm laws? In particular, the research focus is on the ease with which people can acquire and possess guns in different states and the rate at which incidents of mass shootings in these states occur.

DATASET

Data visualization starts with datasets. The study is based on data collected from several sources, including the Stanford University Library, FBI, Shooting Tracker, Gun Violence Archive, and Mother Jones databases. Additional sources include Law Center to Prevent Gun Violence, GUNS & AMMON, and "24/7 Wall St". A consolidated dataset composed of 1466 records spanning several decades (1966-2016) has been created. For each attack, the following information is included in the dataset: name, gender, age, race, date of birth, job, level of education, mental illness status, legal status of the firearms used, and motive. An indicator of whether or not the shooter died during the incident is also included.

Since there is no agreed upon definition for "mass shooting" (Bjelopera et al., 2013), the term will be defined using the five sources listed in Table 1 in this study. We include incidents in this study that satisfy any of the conditions given in the table.

The objective of the study is to understand the impact of the ease of owning or carrying a firearm on the number of mass shooting attacks in the United States. The scope of the research covers the analysis of mass shooting incidents in the United States between 1966 and the first quarter of 2016.

FIREARMS AND MASS SHOOTINGS

In this section, first we present a series of visual descriptions of mass shooting incidents from 1966 to 2016. Then we create an overall measure for firearm laws in a state. Using the new metric, we analyze the relationship between firearm laws and number of mass shooting incidents.

Descriptive Statistics

The dataset used in this study contains data about 1466 mass shooting incidents that occurred in the United States between 1966 and the first quarter of 2016. In describing the main characteristics of the datasets, a series of visuals are prepared. There are array of choices of all types of visuals available. The choices in this study follow the general best practice of visualization principle to suit the data and serve the purposes (Evergreen, 2016).

Descriptive statistics show that the majority of the perpetrators of these attacks were males between the ages of twenty and forty with administrative or clerical jobs. Nearly eighteen percent of the mass shooting attacks occurred at entertainment venues. Figure 1 displays the locations of these attacks by state. Figure 2 shows that majority cases have no reports of the legality of the firearm. 57 percent of the known cases acquired the weapon in an illegal fashion.

FIGURE 1
Distribution of mass shooting attacks in the United States (1966-2016)
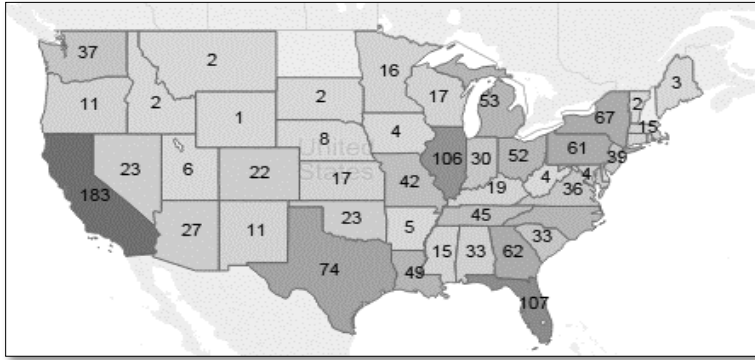

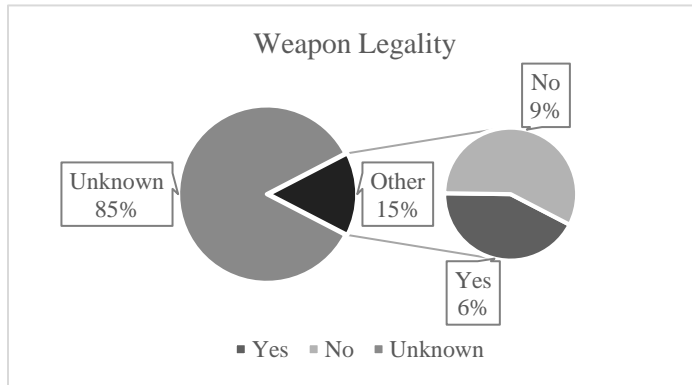**FIGURE 2**
Legality of Firearms

Figure 3 reports the type of firearm used in the 1466 cases in which a firearm type is available in the dataset. Figure 4 shows the legal status of firearms used in mass shootings by perpetrators classified as having and not having a mental illness. This figure shows that despite legislation limiting access to firearms by people with mental illness, 55 percent of the perpetrators of mass shootings classified as having a mental illness used a legal firearm. More details about descriptive statistics are included in Appendix A, which is in a compact poster format.

Based on a report from FBI, on average, approximately 400,000 firearms were registered each year in the United States since 2012 (Federal Bureau of Investigation, 2016). Figure 5 and Table 2 show the correlation between the number of registered firearms in the United States and the number of mass shooting attacks by states from 2012-2015. In this analysis, we only include states in which mass shooting occurred during that year. Thus, there are only 155 observations. An upward trend is shown in the scatter plot.

FIGURE 3
Firearm types used in mass shootings

The Law Center to Prevent Gun Violence is a national public law center that has conducted research on gun violence for more than twenty years. Its primary goals are to minimize gun violence and provide information and analysis to guide policy makers in the United States. In the past several years, the center carried out a study and ranked all fifty states based on the strengths and weaknesses of the gun related laws implemented in that state (Law Center to Prevent Gun Violence, 2016). In this ranking, more weight is given to states that require permits for private purchases because this helps close the loophole and prevent the wrong people from having access to weapons. In brief, gun laws such as prohibiting domestic violence offenders from accessing guns, limiting bulk firearms purchases, and preventing people on the terror watch list from buying guns earn states points in this ranking. On the other hand, laws that permit guns in schools and bars, allow concealed carry in public without a permit, and "Stand Your Ground" laws reduce states' points in the ranking. In addition, preemption laws at the state level that prohibit local governments from passing their own gun ordinances cause states to lose points in this ranking (Law Center to Prevent Gun Violence, 2016).

FIGURE 4

Legality of Firearms used versus history of Mental Illness

Mental Illness History and Legality of Firearms used
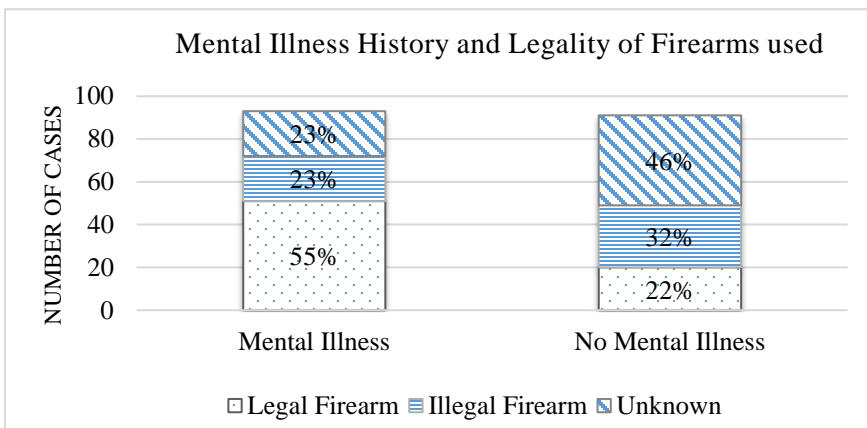
Gun Law State Scorecard by Law Center to Prevent Gun Voilence

States are given an overall score ranging from A to F based on the overall strength of the laws enforced in a state. The analysis done by the center shows that the states with weaker laws are the states with more gun violence although the analysis included gun violence generally and not mass shootings specifically. The scorecard can be found at http://gunlawscorecard.org/.

FIGURE 5

Scatter Diagram of Registered Weapons versus Number of Attacks

Registred Weapons versus attacks (2012-2015)
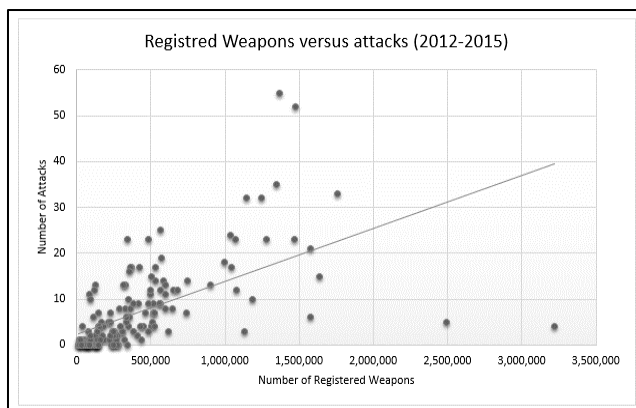
Best States for Gun Owners by GUNS & AMMO

GUNS & AMMO is a magazine that collects, analyzes and shares reviews, news and articles about firearms (Wood, 2015). In 2013, GUNS & AMMO began assessing state gun laws and created a ranking of states from worst to best from the perspectives of their readers who generally own guns. The five categories used in the ranking are (1) Right to carry; (2) Black Rifles (also called modern sporting rifles), restrictions on semiautomatic firearms not regulated by National Firearm Act (NFA); (3) Presence of the Castle Doctrine (laws that protect the principles of self-defense and property rights); (4) National Firearms Act (NFA) in the state that regulates the sale, transfer, and possession of firearms; and (5) Miscellaneous category. The miscellaneous category is used as tie-breaker if states have the same score. Examples of factors include availability of shooting opportunities in a state and availability and popularity of either organized or informal shooting sports.

TABLE 2
Regression Statistics

Multiple R	0.585903503
R Square	0.343282915
Adjusted R Square	0.338990647
Standard Error	7.605516716
Observations	155

As part of this study, the ranks of the states were collected from GUNS & AMMO reports and analyzed with respect to mass shootings for 2013, 2014, and 2015. In 2015, the worst state was Washington DC (ranked 51), followed by New York, New Jersey, Massachusetts, Hawaii, and California. The best states were Arizona (ranked 1), followed by Vermont, Alaska, Utah, and Kentucky (Wood, 2015). In 2014, Georgia was ranked the third best state (G&A, 2014). The other state rankings were stable. We used the 2015 rankings in our analysis.

Figure 6 and 7 shows the five worse and best states to own a firearm with the number of mass shootings per million people. The best states to own firearms in tend to be rural while the worst states tend to be more urban. One difference seen in the charts is New York state which has a large number of attacks, but adjusted for population is below the national average. When adjusted for population, the best states to own firearms are not all below the national average of number of attacks.

A Comprehensive Scorecard

We developed a third scorecard, called comprehensive scorecard, to evaluate state gun laws. In this new metric, for each state, seventeen indicators were collected

to give a broad view of the status of firearm transactions in that state. The selection of the seventeen indicators was informed by the two ratings previously discussed.

FIGURE 6
Number of Mass Shootings per Million People in Five Worst States to Own Firearms
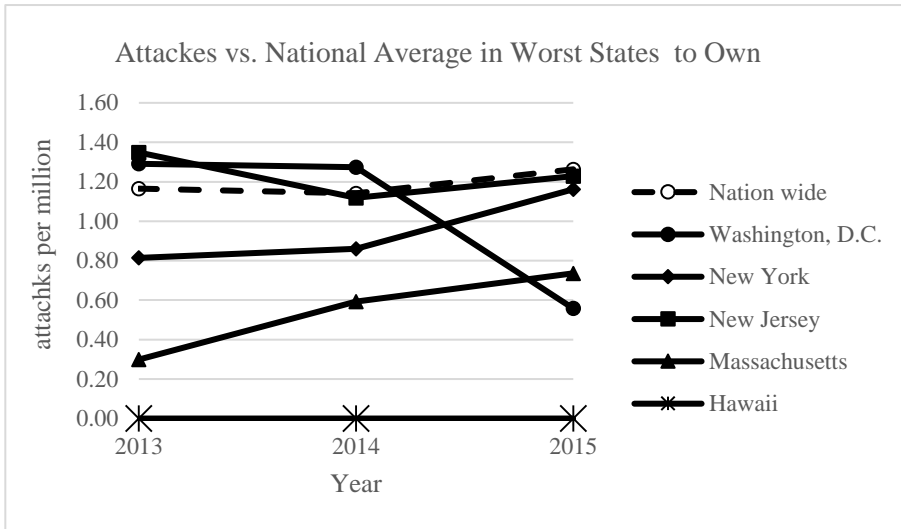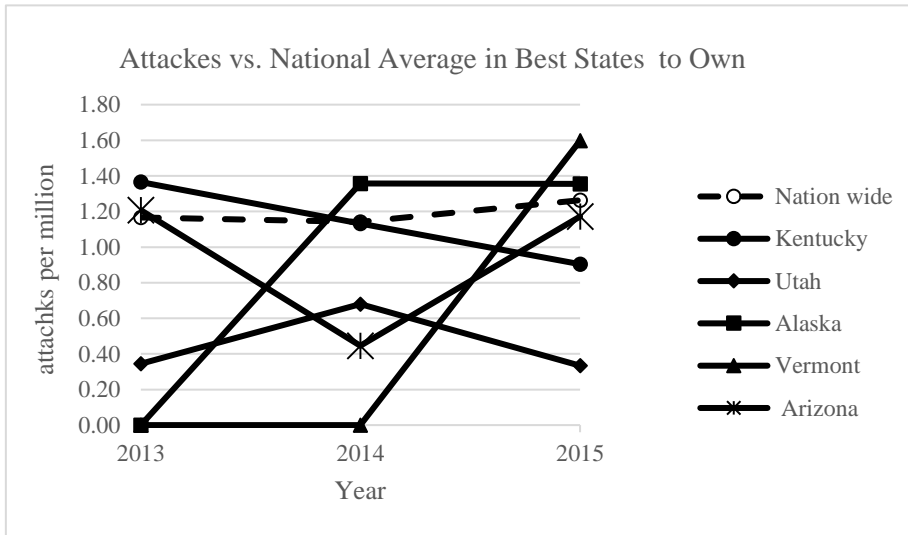

FIGURE 7
Number of Mass Shootings per Million People in Five Best States to Own Firearms

The indicators in the third scorecard are:
1. Permit required for purchasing rifle.
2. Permit required for purchasing hand gun.
3. Owner required to license rifle purchased.
4. Owner required to license handgun purchased.
5. Permit required for carrying rifle.
6. Permit required for carrying handgun.
7. Permit required for open-carry for rifle.
8. Permit required for open-carry for handgun.
9. Permit required for transferring rifle privately.
10. Permit required for transferring handgun privately.
11. Limit on the number of firearms purchased at one time.
12. Impose waiting-time period before taking the firearm. (*)
13. Owner needs to pass weapon usage test.
14. Regulations on "Gun show" in the State.
15. Safety certificate required for old firearms.   (**)
16. Dealers need state license or not.
17. Reporting lost or stolen firearms.
* Specifying the number of days before which the purchaser can take the firearm.
**Tests to ensure the safety of the firearm (Proof Test - Endurance Test - Drop Test).

To gather state by state information, we mainly used information published by the Law Center to Prevent Gun Violence (http://smartgunlaws.org/facts/statistics/). For each state, a summary of state firearm laws was presented; ninety percent of the data used were from this source with the remainder coming from Wikipedia (https://en.wikipedia.org/wiki/Gun_laws_in_the_United_States_by_state).

For each indicator, if there is a permit required from individuals or dealers then the state gets '10' points, while the state loses '10' points (negative 10) if no permit is required or law enforced, and '0' if there is no available information about whether the law is enforced. In cases in which the law is partially enforced with some exceptions allowed, the state earns 5 points instead of 10. The majority of the indicators are focused on handguns, both manual and semiautomatic, and rifles as they were the top firearms used based on the data collected for the 1466 attacks.

The scores of the fifty states range from -110 to 100, with a higher score indicating that more laws are enacted and enforced in that state. The largest number of indicators implemented in a state is 14 but because some of them were only partially implemented no state received 140 points. The top five strong states in terms of laws for getting firearms are California, New Jersey, Connecticut, Massachusetts and Maryland while the bottom five are Tennessee, Florida, South Carolina, Vermont, and West Virginia. A complete list of the states and their scores can be found in Appendix B.

For the 17 indicators, the number of states that have laws, the number of states that have no such laws, and the number of states that have partially imposed laws are shown in Figure 8. We can see the majority of the states, approximately 70%, do not set laws for purchasing handguns. 75% of the states do not impose any laws limiting the number of firearms that are allowed to be purchased in a single transaction and 60% of the states do not require dealers to have a state license for their operations. Approximately 30% of the states do not require individuals to report stolen or lost firearms. Two of the riskier indicators are permits required for private sales of rifles and permits required for private sales of handguns because private sales are tracked by few states. 64% of the states allow private sales of handguns without any permits, while 75% of the states allow private sales of rifles without any permits.

FIGURE 8
Count of States over the 17 indicators
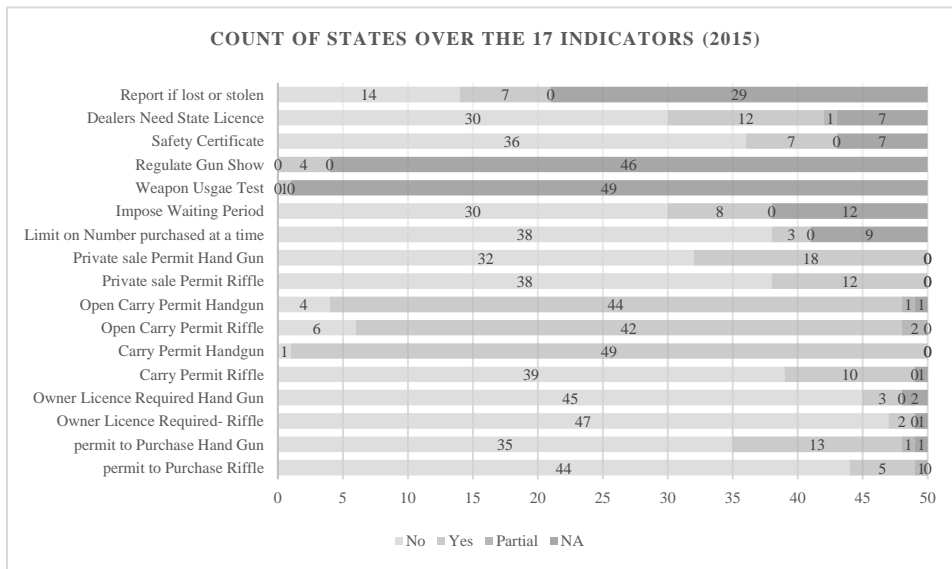
Figure 9 shows a scatter plot of state score versus the number of mass shootings in 2015. The trend line indicates an upward direction. More restrictive laws are associated with more mass shootings.

In Figure 10 a similar scatter plot shows state ranks versus number of mass shooting in 2015. The rankings are based on state scores: the highest score is ranked as 1 (the most restrictive) and the lowest score is ranked as 50 (the least restrictive). A downward trend line is shown in the plot. The two graphs are consistent, although it may seem counterintuitive. However, neither of the correlation coefficients are statistically significant.

FIGURE 9
Scatter Plot of State Scores vs. Number of Mass Shootings

FIGURE 10
Scatter Plot of State Rankings vs. Number of Mass Shootings

When we consider state populations, the direction of the line is reversed. Please see the following two scatter plots (Figure 11 and Figure 12). That is the stricter the firearm laws the fewer incidents per million people in that state. However, again, neither of the correlation coefficients are statistically significant.

FIGURE 11

Scatter Plot of State Rankings vs. Number of Mass Shootings (per million)
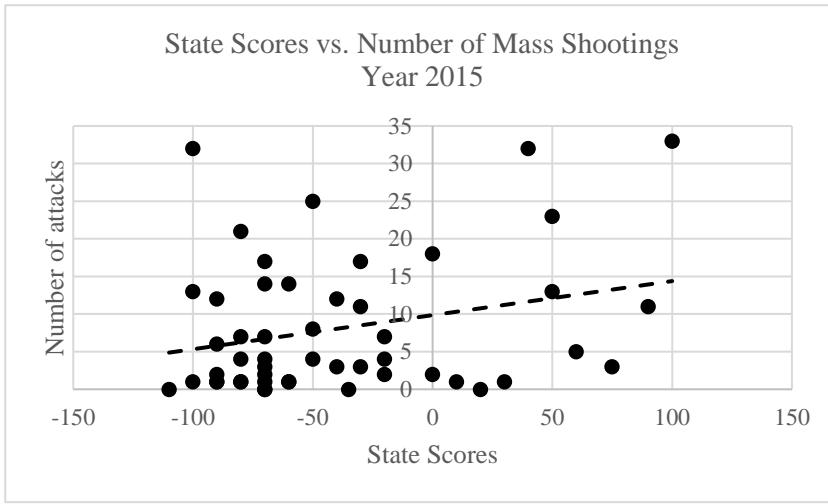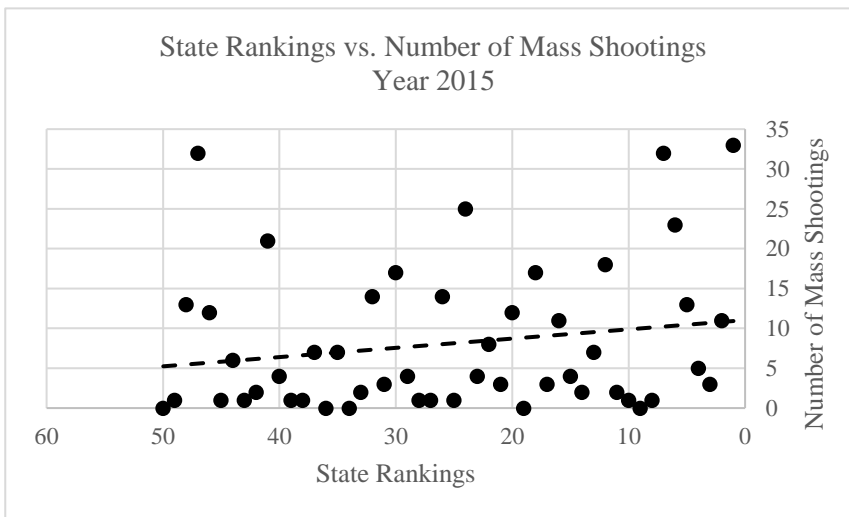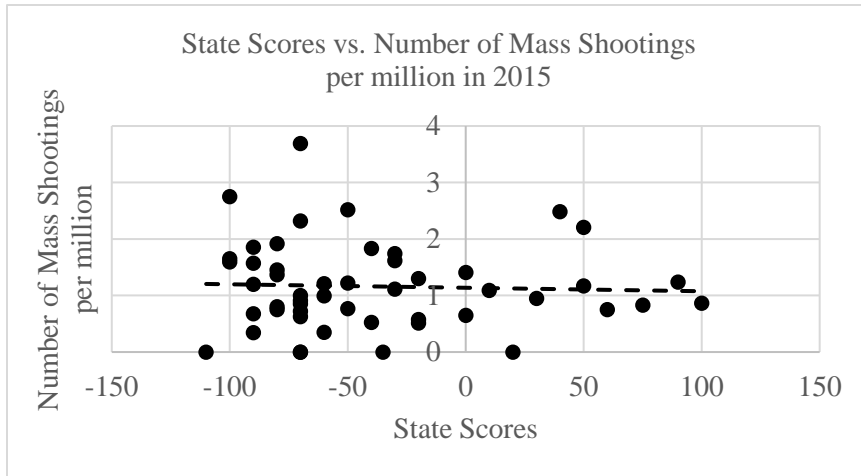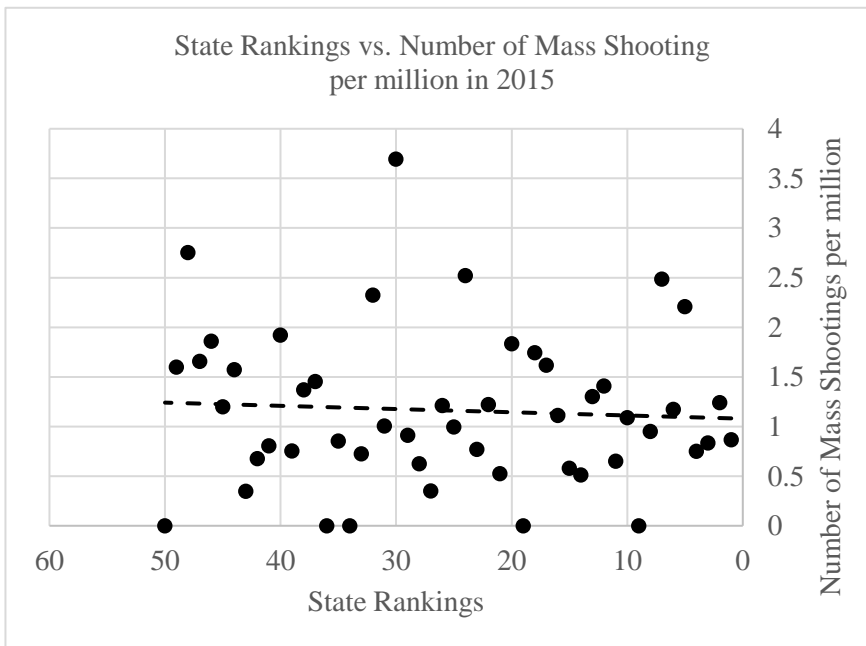

State Scores vs. Number of Mass Shootings
per million in 2015

FIGURE 12

Scatter Plot of State Rankings vs. Number of Mass Shootings (per million)

State Rankings vs. Number of Mass Shooting
per million in 2015

The Three Scores: Some Comparison

The three maps for the United States in Figure 13 show the variation in the strength of laws restricting firearm ownership using the three methods discussed earlier, where the states shown in darker grey have very restrictive laws and the states shown in lighter greys have almost no restrictions. The color bar below the three maps shows the range of colors used from very strong to weak.

Figure 13
Ranking of States by three different methods

(A) Comprehensive Scorecard   *(B) Law Center Rank*   *(C) GUNS & AMMO Rank*

restrict ▮▮▮▮▮ **loose**
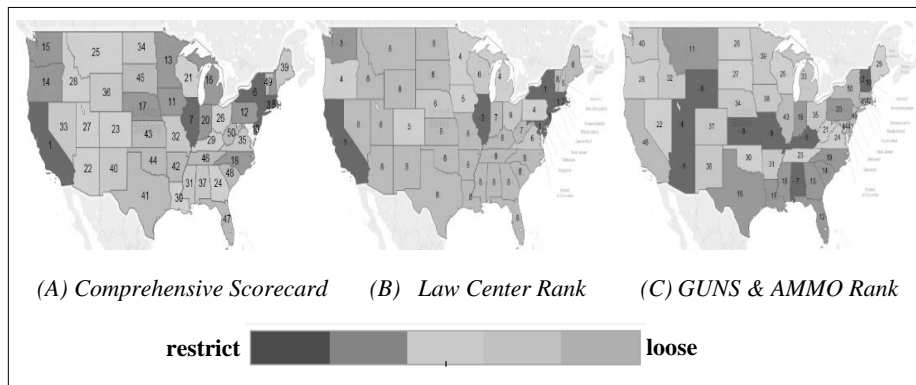
The comprehensive scorecard (the method developed in this paper) shown in (A) represents a midpoint between the rankings of the other two methods. The Law Center for Gun Violence's ranking is very strict and categorizes many more states in the Lowest Class "F grade." GUNS & AMMO classifies the states with weak laws as the best states from the purchaser's perspective. However, it includes many factors into five broad categories and gives a state an overall score on that category. The comprehensive scale proposed here classifies the states from a public safety perspective and includes many indicators that allow us to differentiate the states. It may help identify states and regions in need of improvement.

To effectively compare the Law Center for Gun Violence scorecard and our comprehensive scorecard, the states were divided into sub-groups based on their scores and grades. Each group was given a color based on a color scheme presented in Table 3 and Table 4. We can see that more than half of the states were rated F using the Law Center Grade. State scores by our comprehensive score are much more evenly distributed, especially at the lower end of the spectrum, although the two worst groups still make up more than half of the states. This classification suggests that it may be effective to target fourteen states for change rather than 26.

TABLE 3
Law Center Grade

Law Center Grade	Color Zone	Number of States
A-	Green Zone	6
B+	Light Green Zone	1
B	Light Green Zone	1
B-	Light Green Zone	3
C	Yellow Zone	4
C-	Yellow Zone	2
D	Orange Zone	5
D-	Red Zone	2
F	Dark Red Zone	26

TABLE 4
Comprehensive Scorecard

Comprehensive Score	Class/Group	Color Zone	Number of States
(76-100) Points	A	Dark Green Zone	2
(51-75) Points	B	Green Zone	4
(26-50) Points	C	Light Green Zone	2
(1-25) Points	D	Yellow Zone	2
(-24 - 0) points	E	Dark Yellow Zone	2
(-49 – -25)Points	F	Orange Zone	3
(-74 - -50) Points	G	Light Red Zone	6
(-99 - -75) Points	H	Red Zone	15
(-124- -99) Points	I	Dark Red	14

DISCUSSION

The first takeaway of this study is that the relationship between state firearm laws and the number of mass shooting incidents is not a simple one. Firearm laws are mixed bag of many regulations. All the ratings of states try to provide an overall indicator, including ours. With the advantage of being simple, they suffer from being grossly aggregated. Maybe this is one of the reasons that we did not find significant correlations between number of mass shooting incident and state scores and rankings. A more detailed approach focusing on individual regulations may produce significant results.

With that said, we still can draw some implications of our results. In 2015, a positive correlation was seen between the restrictiveness of firearm laws and the number of mass shootings. However, when adjusted for population a slight negative correlation is seen. That is, the number the mass shootings per million people is fewer in the states with more restrictive firearm laws. Keep in mind that

none of the correlation coefficients are statistically significant. Another commonly discussed issue with data is that some laws are put in place as a response to previous incidents. Thus, the effect of firearm laws is best analyzed in a lagged fashion. Our approach argues that when one considers firearm laws at the state level as a whole rather than focusing on individual laws gives a measure of the gun culture and overall attitude towards gun ownership in a state. Thus, the rate of mass shooting incidents in the United States may be reduced through changes in firearm regulations at the state level, which send the public a signal of low tolerance of gun violence. This can serve as a deterrence factor for future.

The positive correlation between the number of firearms registered through the FBI and the number of attacks reveals the importance of tracking these numbers on a frequent basis by the administrative divisions of the United States in order to set preventive actions to reduce the rate of mass shootings.

The comprehensive scorecard based on the seventeen indicators represents a neutral method that considers diverse factors when comparing and contrasting different states. The ranking system of the Law Center to Prevent Gun Violence and GUN & AMMO are too strict, broad, and generic. This causes the placement of the majority of states in the same class despite variation the enforcement of gun laws. The comprehensive scorecard enables a more detailed view of the status across the states that may facilitate the development of action plans for improvements. A more detailed system may guide policy makers to set actions to enhance firearm regulations on the state level to decrease the number of mass shootings. We further suggest using the color scheme presented in Table 4 to create data visuals in regards to firearm regulations, so that different groups of states are easily identified. An example is shown in Figure 14.

Significant data challenges pose limitations to the conclusions reached in this study. Although the dataset used in the study is as complete and accurate as possible, the dynamic nature of state laws meant that we were limited to only a subset (in 2015) of the data for the major part of the analysis in this paper. Thus, the study provides a snapshot of a very complex phenomenon. Ideally, a longitudinal approach is needed to study the long-term effect of a particular law and regulation.

According to Guns & Ammo (Wood, 2015), the worst states to own firearm may become even worse and the best may become even better. For example, New York State, one of the worst, is set to ban 0.50-caliber rifles and require gun owners to lock up their firearms while at home. On the other hand, in 2015 Utah discussed permitless carry. What are the effects of these changes in state laws on mass shooting? There is a need for ongoing effort in data collection and systematic examination on this important issue.

Figure 14
Bubble Diagrams of Comprehensive Scorecard
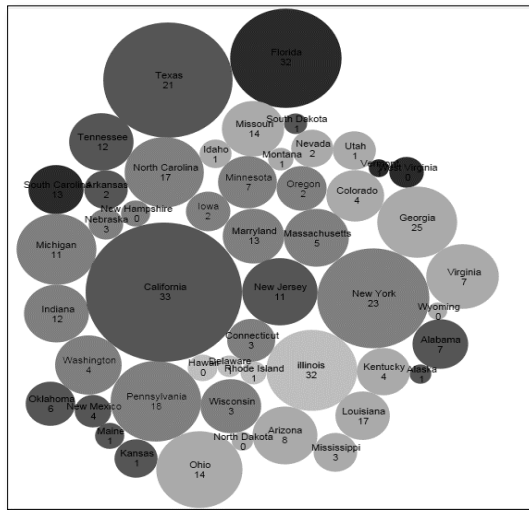
CONCLUSION

This study focused on the relationship between state-level firearm laws and the number of mass shootings. The dataset of mass shooting incidents used in the study was compiled from multiple sources and will be made available to the public. Our analysis showed correlations of state firearm laws and the number of mass shootings to some degree, which suggests that more restrictive firearm laws may decrease the number of mass shooting attacks. However, we have to take this with a grain of salt because the non-significant nature of the correlation. On the other hand, although our findings are far from conclusive, we paint a clearer picture of mass shootings in the last five decades.

Another contribution of the study is the creation of the comprehensive scorecard based on seventeen indicators. It represents a more comprehensive, detailed, and neutral system compared to the Law Center Grade and GUN & AMMO rankings. More importantly, it allows more differentiation among the states, which provides a better basis for action at the state level.

In addition to implications for policy in the area of gun control, this study provides an example of case study using data visualization approach in a situation with less agreement on theories and prior research. New and available technologies enable the wide adoption of the data visualization as a common practice in organizations to assist decision-making and communication. Many business programs have incorporated business analytics and data visualization into their curriculum to

better prepare their graduates. Data visualization skills, together with research skills and critical thinking skills, are better practiced with real projects. Exploring a topic from data collection to data analysis, from data cleaning to communications of results by carefully produced visuals will be very beneficial. Although the scope and complexity of this project is beyond the capability of a regular course, it provides a model for such curriculum consideration.

Notes:
- Dataset of mass shooting from 1966 to 2016 is available upon request.
- Visuals in the final production of the article are rendered and modified to be black and white in order to meet the printing requirement. Color copies are available upon request.

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Appendix A: Descriptive Statistics of Mass Shooting Incidents from 1966-2016 (Quarter 1)

Gender

594 97%   21 3%

615 Records

Age

Shooters Age Distribution

100% · 90% · 80% · 70% · 60% · 50% · 40% · 30% · 20% · 10% · 0%

2   16   3
45
81
114
162
82
14   1

Age Count

520 Records

- 80's
- 70
- 60's
- 50's
- 40's
- 30's
- 20's
- High School (15-19 Years)
- Middle School (11-14 Years)
- Elementary School (10 Years or Younger)

Jobs

Number in Brackets reflect the number of Shooters

[19] Police-Navy-Army-Marine (current/Ex)

[3] Drivers   [5] Medical: Doctor/Nurse/ Pharmacist   [13] Managerial Position Business owner

[1]Building / Construction   [10] Engineer/ Technician   [1]Cook   [9]Peet Officer   [6]Prof/Teacher /Coach

[16] Administrative/Clerical work/Logistics/Support Functions   [16] Worker (i.e. Baker, painter factory worker, farmer, dishwasher, baby sitter, guard...etc.)

[10] Unemployed, [51] students,   [6] Art & Design, [2] Lawyer,   [2] Reporting & Press   * Rest unknown

Level of Education

Weekdays vs. Weekend

1466 Records

Day of Week *
- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Location

R 7   G 7   A 2
H 41
I 22   O 55   F 6   J 11
E 26   D 262   K 6
P 380   M 28
L 366   Q 26   N 83   C 49

Location Mapping

A: Airport
B: College/University
C: Factory/Company/ Office/Workplace
D: Entertainment Venue/Event
E: Government Facility
F: Hotel/Motel
G: Medical/Care
H: Park
I: Parking Lot
J: Worship Place
K: Public Transportation
L: Resident Home/Neighborhood
M: Restaurant/Café
N: Retail/Whole Sale/Services Facility
O: School
P: Street/Highway
Q: Transportation
R: Military Facility

1417 Records

Appendix B: Comprehensive Scorecard of States of 2015

State	Sum	Rank	Classes	Attacks 2015	Population 2015	Ratio
California	100	1	A	33	37999878	0.868423841
New Jersey	90	2	A	11	8867749	1.240450085
Connecticut	75	3	B	3	3591765	0.835243954
Maryland	50	5	B	13	5884868	2.209055496
Massachusetts	60	4	B	5	6645303	0.752411139
New York	50	6	B	23	19576125	1.174900548
Illinois	40	7	C	32	12868192	2.48675183
Rhode Island	30	8	C	1	1050304	0.952105295
Delaware	10	10	D	1	917053	1.090449516
Hawaii	20	9	D	0	1390090	0
Iowa	0	11	E	2	3075039	0.650398255
Pennsylvania	0	12	E	18	12764475	1.410163755
Minnesota	-20	13	F	7	5379646	1.30120086
Oregon	-20	14	F	2	3899801	0.512846681
Washington	-20	15	F	4	6895318	0.580103775
Indiana	-40	20	G	12	6537782	1.835484879
Michigan	-30	16	G	11	9882519	1.113076534
Nebraska	-30	17	G	3	1855350	1.61694559
New Hampshire	-35	19	G	0	1321617	0
North Carolina	-30	18	G	17	9748364	1.743882358
Wisconsin	-40	21	G	3	5724554	0.524058293
Arizona	-50	22	H	8	6551149	1.22115983
Colorado	-50	23	H	4	5189458	0.770793405
Georgia	-50	24	H	25	9915646	2.521267903
Idaho	-70	28	H	1	1595590	0.626727417
Kentucky	-70	29	H	4	4379730	0.913298308
Louisiana	-70	30	H	17	4602134	3.693938508
Mississippi	-70	31	H	3	2986450	1.00453716
Missouri	-70	32	H	14	6024522	2.323835816
Montana	-60	25	H	1	1005494	0.994536019
Nevada	-70	33	H	2	2754354	0.726123076
North Dakota	-70	34	H	0	701345	0
Ohio	-60	26	H	14	11553031	1.211803206
Utah	-60	27	H	1	2854871	0.350278524
Virginia	-70	35	H	7	8186628	0.855052898
Wyoming	-70	36	H	0	576626	0
Alabama	-80	37	I	7	4817528	1.453027362
Alaska	-80	38	I	1	730307	1.369287163
Arkansas	-90	42	I	2	2949828	0.678005633
Florida	-100	47	I	32	19320749	1.65625049
Kansas	-90	43	I	1	2885398	0.346572639
Maine	-80	39	I	1	1328501	0.752728075
New Mexico	-80	40	I	4	2083540	1.919809555
Oklahoma	-90	44	I	6	3815780	1.572417697
South Carolina	-100	48	I	13	4723417	2.752244826
South Dakota	-90	45	I	1	834047	1.198973199
Tennessee	-90	46	I	12	6454914	1.859048781
Texas	-80	41	I	21	26060796	0.80580808
Vermont	-100	49	I	1	625953	1.597564034
West Virginia	-110	50	I	0	1856680	0