

# Mass Shooting Intervals

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## 1 Abstract

Lin et al. (2018) found that the time interval between mass shootings has been drastic decreasing in the past three decades, suggesting that the rate of shootings are increasing. I was able to replicate all of the results from Lin et al. (2018), but while I was able to replicate the inconclusive results in table 1, I was not able to replicate the exact zero-inflated Poisson model. My extension broke down the interval trends between different venues of shootings showing in figure 2 of Lin et al. (2018). I found that the interval trend of mass school shootings remained relatively steady while the interval between mass workplace shootings and other mass shootings drastically decreased since 2008. This suggests that more research should be done looking at why workplace mass shootings has specifically increased drastically since 2015.

## 2 Introduction

The main finding by Lin et al. (2018) was that the model they created using associated risk factors for mass shootings such as gun ownership, mental illness, poverty, and gun laws provided inconclusive results when predicting the number of mass shootings per state they looked at from Mother Jones. Mark Follman (2020) However, the authors also found importance evidence surrounding the interval between mass shootings. Overall, they found that the interval between all mass shootings has been on the decline since the 1982, the year of the first mass shootings in the Mother Jones dataset. Mark Follman (2020) Additionally, they also found evidence of a correlation between an increasing media coverage and online search interest of mass shootings and the decreasing interval of mass shootings. However, the authors only looked at online reports and did not include data from social media coverage or interest surrounding mass shootings.

I was able to replicate all the results found by Lin et al. (2018). The authors kindly made the data available alongside their paper. Ping-I Lin (2018a) However, the original code used for the graphics was not included with the paper and I was unable to access the original code. As a result, I was unable to recreate the exact zero-inflated Poisson model in table 1 of the paper. Instead, I created a Poisson model using a Bayesian

regression modeling package that produced the same inconclusive results. Jonah Gabry (2020) My replication was done in R and is public ally accessible via GitHub.<sup>1</sup> Foundation (2020)

My extension focused deeper in the decreasing interval between mass shootings. Specifically, I broke down the overall decreasing interval into the three most popular venues of shootings: school, workplace, and other. Then, I recreated figure 2 from Lin et al. (2018) only separating the three categories. The results show that the interval between mass school shootings has stayed relatively flat and has not changed significantly since 1982. So, mass school shootings had a relatively low impact on the overall decreasing interval between mass shootings. Instead, the decrease was a result of mass workplace shootings and other mass shootings.

### 3 Literature Review

This study resulted from limited published findings in the past and wanted to identify some risk factors associated with mass shootings. As a result, the authors wanted to answer three specific questions related to mass shootings in this paper. 1. “What are the population-level factors associated with the probability of mass shootings?” 2. “Is the incidence rate of mass shooting increasing during the past three decades?” 3. “Is the online media associated with the probable ‘contagious effect’?” The specific factors looked at in this paper include: “state-level gun ownership rate, serious mental illness rate, poverty percentages, and gun law permissiveness”. To evaluate if there was an increase in mass shootings in the past three decades, the authors looked at data regarding “mass shootings that occurred within the U.S. in the past 30 years”. The authors of the paper defined mass shooting “as an act of firearm violence that resulted in at least four fatalities (not including the perpetrator), at the same time, or over a relatively short period of time in the case of shooting sprees”. The contagious effect is like a copy cat effect, where if one mass shooting occurs, it promotes the increase of “copy cats” or more mass shootings in the time that follows.

The authors findings ultimately reached inconclusive evidence for looking at the relationship between risk factors and the number of mass shootings. One of the main difficulties with looking at risk factors for mass shootings is the relatively small amount data on shootings that researchers have to look at. However, they did find the the interval between mass shootings has been steadily decreasing for the past three decades. Further, they found evidence of possible relationship between the increasing amount of media coverage of mass shootings and this interval decrease. However, the research done by Lin did not look at the specific number of social media posts mentioning mass shootings, only Google search results and Google trends. This is an area where research should be done because of the increasing popularity of social media, especially among the youth. Overall, the research done by Lin provided important information around the decreasing intervals which can be useful for further research to see how the interval trends have changed since the paper’s publication.

In the overall category of research related to mass shootings, there have been two areas of main focus, continuing to look at what risk factors relate to mass shootings the most and domestic violence restraining order (DVRO) prohibition laws. In the focus of looking at risk factors, many other papers have also reached inconclusive evidence on many of the same factors that Lin looked at. Other papers have cited similar a similar issue with the lack of data to provide any substantive conclusions on risk factors. However, a recent Webster et al. (2020) paper found that more firearm purchaser licensing requirements are likely to reduce the number of mass shootings as it makes it more difficult for high-risk individuals to purchase guns. Daniel W. Webster (2020) Regarding the focus on DVRO, there was a lot of excitement around a paper by Zeoli et al. (2017) because he had found evidence that DVRO laws can significantly reduce the number of shootings related to domestic violence. April M Zeoli (2017a) This would have been a huge finding since many mass shootings are related to domestic violence. However, the paper by Zeoli et al. was later retracted shortly after due to errors within dates they used which led to the significance of DVRO laws to fade. April M Zeoli (2017b)

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<sup>1</sup>GitHub

## 4 Replication

I was able to replicate all of the findings from Lin et al. (2018) from the inconclusive results of using the risk factors to try and predict the cause of mass shootings to the decreasing interval between mass shootings over time and over media coverage density. However, while I was able to replicate the inconclusive results of using risk factors to try and predict the number of mass shootings per state, I was unable to replicate the exact zero-inflated Poisson model created by Lin et al (2018). This was mainly due to not having the original code used to make the model available and my unfamiliarity with zero-inflated Poisson models. Instead, I created a Poisson regression using a Bayesian regression modeling package in R. Jonah Gabry (2020) Foundation (2020)

## 5 Extension

I extended Lin et al. (2018) by taking into account the venue of the mass shootings from 1982 to 2018 and visualizing the trends between the three largest categories: School, Workplace, and Other. Additionally, I downloaded the updated mass shooting dataset from Mother Jones' and created the same visualization with the three largest venues with data up to 2020. Mark Follman (2020)

### 5.1 Venue Categories

Throughout Lin et al. (2018), the authors categorized every mass shooting in the data into one. However, the shooters' motive is an important factor when studying the causes for mass shootings and trying to prevent future shootings. Looking at all the venues of shootings categorized in this dataset, it would be natural to assume that the shooters' would have varying motives: Airport, Military, Other, Religious, School, and Workplace. For example, a shooter who attacks a religious venue might have racist motives while a shooter who attacks a school might have been acting on revenge against bullies. So, I decided to break down figure 2 by Lin et al. (2018) into three venue categories: School, Workplace, and Other. I chose these three because they were the three most common venues and the others all had five or less shootings. To keep the number of datapoints that same, I put these smaller venues into the category of Other.

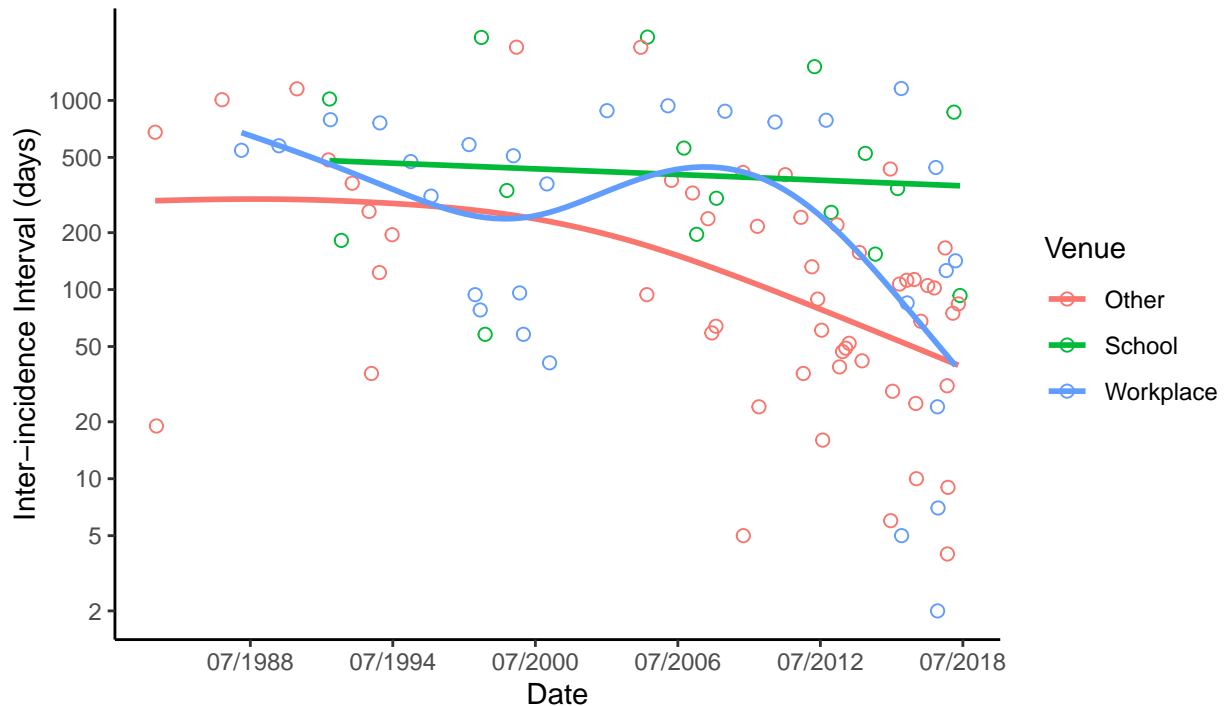


Figure 4. Interval time between mass shootings based on venue. Trends using GAM

The results reveal some interesting information between the three venues. When broken down into more specific categories, the trends show that not all venues have seen an equal downward trend in intervals between shootings. The trend looking at mass shootings at schools is perhaps the most interesting, as it shows only a slight decrease overall. This suggests that the number of mass shootings at schools today might not actually be much different than in the 80s. The trend seems to hover around every one year. On the other hand, the interval between mass shootings at workplaces has drastically fallen since around 2015 from one every few years to one every month in 2018. Before that, the interval seemed to be increasing from one every 200 days in 2000 to one every few years in 2008. This is an interesting trend because workplace mass shootings might not be as frequently reported on in comparison to mass school shootings which gain national media attention. Looking at shootings that occurred in other venues, the trend aligns closer to the overall trend in figure 2 by Lin et al. (2018) of an overall decreasing trend in the interval between shootings.

## 5.2 2020 Data

Bringing in the new data on mass shootings from Mother Jones', I created the same three categories of venues and created a similar visualization. Mark Follman (2020) Since 2018, there has been no new mass shootings that occurred at a school, so that trend does not change. The trend on workplace mass shootings has decreased slightly from every month to about every month and a half. This might suggest that the trend is flattening out.

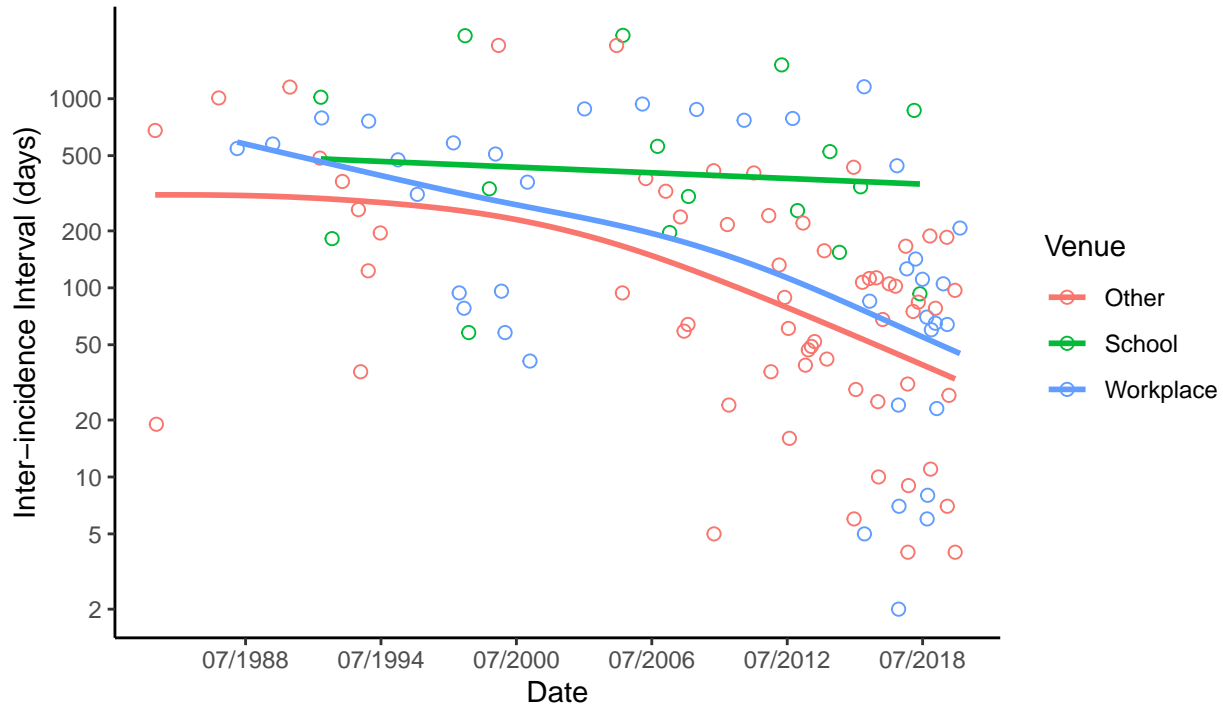


Figure 5. Interval time between mass shootings based on venue. Trends using GAM

## 6 Discussion

While the finding by Lin et al. (2018) regarding using associated risk factors to predict the number of mass shootings per state were inconclusive, the other findings regarding a the decrease in mass shooting intervals provides early warning signs that not enough is being done to prevent mass shootings. The original findings suggest that the interval between all mass shootings since 1982 has decreased from the average of a shooting every 200 days to a shooting every month. Furthermore, the data comparing mass shooting intervals and media coverage and online search interest suggest that there could be a correlation between increased attention and a lower interval.

My replication confirmed the results in Lin et al. (2018). While the code for the paper was not available, the data was published alongside the paper. Ping-I Lin (2018a) The only graphic that I was unable to fully reproduce was the regression zero-inflated Poisson model that provided inconclusive evidence of predicting the number of mass shootings per state by risk factors. Instead, my Poisson regression model was created using a Bayesian regression modeling package in R. Jonah Gabry (2020) Foundation (2020). However, my model confirmed the inconclusive results found by Lin et al. (2018). The code and data used for my replication can be found on my GitHub.<sup>2</sup>

The extension in this replication dug deeper into the decreasing mass shooting intervals by looking at the trends separated by different venues of shootings. From those three venues, I found that school mass shooting intervals trend has remained fairly consistent since 1982, hovering around a median of one shooting every 500 days. However, the mass shooting interval trends of workplace and other venue locations has drastically decreased since 2008. This suggests that more research should be done to try and find the cause of increased workplace mass shootings and other mass shootings in general since 2008, especially focusing on the spike after 2015.

While research surrounding mass shootings has been rising in interest, there is still relatively little research around this in comparison to other types of crime. One cause of this shortage of research might be due to the relatively small amount of data out there related to mass shootings. Another factor that might affect the low number of papers surrounding mass shootings is that the number of mass shootings and the number of victims of mass shootings is relatively much lower than other crimes such as homicides. However, the traumatic effect of mass shootings for everyone in the United States and the fact that mass shootings are much less common in other developed nations show that not enough is being done to try and prevent mass shootings. From the findings by Lin et al. (2018) around decreasing intervals and the findings from my extension around decreasing intervals in the recent years and at workplaces specifically provide specific areas that demands further research for the safety of everyone living in the United States.

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<sup>2</sup>GitHub

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## Appendix

I was able to replicate all the findings from Lin et al. (2018). However, my Poisson regression model showing the inconclusive results of using risk factors to predict the number of mass shootings per state slightly differ from the zero-inflated Poisson model created by Lin et al. (2018). While the results reach the same conclusion, the differences are worth noting. The code to replicate all graphics can be found in my GitHub repository.<sup>3</sup>

Table 1: Effect of Treatment, Time Length, and their Interaction on Change in attitude

Statistic	Mean	St. Dev.
Intercept	1.724	1.879
FS/S	-0.008	0.010
Serious mental disorder rate	-0.090	0.084
Poverty rate	0.059	0.036
Gun law permissiveness	0.191	0.136

The Poisson regression created for the replication.

Parameter	Mean	SD	2.5% Percentile	Median	97.5% Percentile
Intercept	-1.23	2.99	-6.9	-1.49	5.06
FS/S*	-0.35	1.24	-2.82	-0.35	2.19
Serious mental disorder rate	0.02	0.15	-0.29	0.04	0.29
Poverty rate	-0.02	0.05	-0.07	0.018	0.13
Gun law permissiveness	-0.26	0.39	-1.06	-0.25	0.49

\* FS/S denotes the ratio of firearm-related suicides divided by all suicides.

<https://doi.org/10.1371/journal.pone.0204722.t001>

The zero-inflated Poisson model created by Lin et al. (2018). Ping-I Lin (2018b)

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<sup>3</sup>GitHub