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The Effect of Mass Shooting Events on Community Mental Health

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1 Intro

Mass shootings in the United States have been increasing in intensity and frequency in the past two decades (Katsiyannis, Whitford, and Ennis, 2018). Intense public debate and policy discussions are widespread throughout the media as well as increased public scrutiny of the effects of gun violence. The U.S. Congress Joint Economic Committee Democratic Staff (2019), estimated the annual cost of gun violence to be $229 billion, or around $700 per capita. While much research has been done on the effects of trauma or traumatic events on an individual's health and the economic cost, this paper illustrates the relationship between gun violence in the form of mass shootings and its effects on community health (Bharadwaj et al., 2021). We postulate that the total effects of a mass shooting event are more expansive than only outcomes related to victims and survivors. Each community that endures such an event also bear a burden. Empirical evidence on the community spillover effects, precisely community health effects and costs, is limited.

This study seeks to estimate the impact of a mass shooting event on community mental health outcomes in the short and medium term. Empirical challenges include that US counties that experienced a mass shooting event could differ from counties not exposed. Additionally, mass shooting events, through increasing, are relatively infrequent and occur at different times. While it is unlikely that the victims of mass shooting were targeted randomly, it is more plausible that mass shooting events are exogenous to local community mental health trends. We take advantage of detailed health insurance claims data and use a strategy to compare exposed and non-exposed counties with an event study difference-in-differences (DiD) research design.

We document the incidence of 15 mass shooting events over a three-year sample and use detailed health insurance claims to examine trends in mental health diagnosis claims before and after each shooting event. By adding county level characteristics, we can control for time-invariant county characteristics between exposed and non-exposed counties as well as general trends in diagnoses rates. Using an event study DiD empirical strategy we mitigate bias from time-invariant unobserved heterogeneity in exposed and non-exposed counties. With the traditional parallel trends assumption, we estimate the community impact of exposure to a mass shooting event.

Our analysis studies several outcomes at the community level to gain detailed understanding of how pervasive mass shootings are on the mental health of the community. We define the local community at the county level instead of US zip code. While mass shootings almost always occur at a specific location and single zip code, residents of neighboring zip codes are not immune from the effects of the event. Exposure is transmitted via local media coverage and other channels to the broader community (Meindl and Ivy, 2017). We seek to capture more of the exposure by examining outcomes at the county level. We examine the number and frequency of mental health diagnosis health insurance claims as well as whether diagnosis originated in inpatient or outpatient care. We restrict our study to mental health diagnoses related only to stress, anxiety, and depression: a conservative definition of mental health impact.

While mass shooting events certainty affect the overall health, we choose to concentrate on mental health for a number of reasons. First, “mental health problems are the single largest cause of disabilities in the world” as reported by the Pan American Health

Organization in 2019 (Mitchell, 2019). Second, the National Alliance on Mental Illness statistics indicate that mental health conditions are more likely to be acute rather than chronic (Mental Illness, 2022). Finally, at around $700 per capita healthcare spending on mental health is greater than that of spending on obesity and similar to total expenditure per capita on Medicaid (Follman et al., 2018). Thus, understanding the potential determinants of mental health diagnosis are vital for policy makers. Accordingly, mental health outcomes at the county level allows us to study short and medium term community impacts.

Our results for the event study shows counter intuitive results. We find that before the shootings some lags are positive and statistically significant, which suggest that the parallel trends assumption does not hold. This means that we can not estimate a casual effect of the events in the individual mental health claims trends. Also, we found that after the shooting, some leads are positive and statistically significant, which means that the mass shootings would decrease the incidence of mental health claims in the counties affected by a shooting.

Our study contributes to a large cross discipline literature of how violence and mental health are related. Studies in economics focus on survivor outcomes and estimate effects on human capital accumulation and economic outcomes such as employment and income (Bharadwaj et al., 2021; Kim and Albert Kim, 2018; Cabral et al., 2021). Specifically, Cabral et al. (2021) found that mass shootings in Texans schools have a negative impact in education outcomes. They found that absenteeism and grade repetition increased for children exposed to the shooting, and that high school graduation, college enrollment, and college completion are lower in the same group. (Bharadwaj et al., 2021) used data from

Norway to evaluate the impacts of a mass shooting in healthcare usage, mental health and education outcomes. They found that the survivors have lower GPA scores, more healthcare use and mental health diagnosis increase. (Kim and Albert Kim, 2018) studied the impact of the Charlie Hebdo attacks in the French population. They find that the post surveys have lower subjective well-being and mental health measures, which were stronger for immigrants and low-income individuals. We add to this literature by advantageously using medical health insurance claims data instead of individual surveys, and by examining community outcomes as opposed to only survivor outcomes.

Our study is organized by the following. Section 2 describes the data used and provides the precise medical and government definitions of our key variables of interest. Section 3 discusses our empirical research design and strategy to estimate the impact of mass shooting events on mental health incidence. Section 4 presents our results as well as key figures and tables. Section 5 concludes and summarizes our analysis.

2 Data

2.1 Shootings

Data containing information about shootings in the United States was sourced from the Gun Violence archive. The Gun Violence archive is a non-profit organization formed to provide free online access about gun-related violence. This database provides different types of gun violence events in the US, as well as details surrounding the event, including characteristics about the shooter, motive, victims killed and injured, as well as geographic

details. From there, it is necessary to define which events we are interested in. The Congressional Research Service defines mass shootings as multiple, firearm, homicide incidents involving 4 or more victims at one or more locations close to one another (Smart, 2018). Additionally, these events are characterized by their public nature, excluding mass domestic homicides. For the time frame of interest of the years 2008 to 2010, the following 18 mass shooting events, depicted in Figure 2.1, are considered.

Date	City	State	Number Killed	Number Injured
2/7/2008	Kirkwood	Missouri	6	1
2/14/2008	DeKalb	Illinois	5	16
3/18/2008	Santa Maria	California	4	0
6/25/2008	Henderson	Kentucky	5	1
9/2/2008	Alger	Washington	6	4
3/29/2009	Carthage	North Carolina	8	3
4/3/2009	Binghamton	New York	13	4
11/1/2009	Mt. Airy	North Carolina	4	0
11/5/2009	Killeen	Texas	13	32
11/29/2009	Parkland	Washington	4	0
4/3/2010	Los Angeles	California	4	2
6/6/2010	Hialeah	Florida	4	3
8/3/2010	Manchester	Connecticut	8	2
8/14/2010	Buffalo	New York	4	4
9/11/2010	Jackson	Kentucky	5	0

Figure 2.1: Mass Shooting Events in the US, 2008-2010

These mass shootings vary in severity and geographic location. The location data is translated to Federal Information Processing (FIPS) codes which indicate the state and county in one value. This allows for the merging of county/state characteristics (such as population) and medicare claim data with the respective fips in which the event had

occurred.

2.2 Medicare

To determine the changes in outcome of mental health to those exposed to local mass shooting events (within the same county), a measure of mental health is required. As it is not observed which individuals were directly affected by the mass shooting events, nor is it observed which of these individuals developed mental health issues, health insurance claim data from used to gauge the overall health concerns of an exposed county. As it stands, this data is sourced from a synthetic sample of roughly million health insurance claims from Medicare. Medicare is a federally-managed national health insurance program in the United States that has been providing health insurance to over 50 million Americans, mostly at or above retirement age.

Statistic	Mean	St. Dev.	Min	Max
Mental Health Claims	0.032	0.177	0	1
Age	72.765	13.068	24	101
Sex_F	0.582	0.493	0	1
Sex_M	0.418	0.493	0	1
Race_Black	0.100	0.300	0	1
Race_Hispanic	0.020	0.140	0	1
Race_Others	0.034	0.181	0	1
Race_White	0.846	0.361	0	1
Admission_Inpatient	0.079	0.269	0	1
Admission_Outpatient	0.921	0.269	0	1

N: 4,198,855

Figure 2.2: Descriptive Statistics of Medicare Claims and Beneficiaries

Figure 2.2 depicts the composition of mental health claims in the dataset. It should be noted that because these claims are from beneficiaries that are predominantly retired, most the claims are for treatment of older individuals. Specifically, the sample is mostly older, white women, with an average age of almost 73 years. Additionally, admission types are distinguished between inpatient and outpatient claims. Inpatient claims are those treatments that require the beneficiary to stay at the hospital at least overnight. Outpatient claims are for those that are there for short treatments, diagnoses and prescriptions that don't require the beneficiary to stay at the hospital. The most common claims are outpatient claims, and mental health claims are on average only 3.2% of total medicare claims in the sample.

Statistic	Mean	St. Dev.	Min	Max
Mental Health Diagnoses	1.071	0.287	1	5
Age	72.245	13.832	24	101
Sex_F	0.586	0.493	0	1
Sex_M	0.414	0.493	0	1
Race_Black	0.106	0.308	0	1
Race_Hispanic	0.022	0.147	0	1
Race_Others	0.035	0.184	0	1
Race_White	0.837	0.370	0	1
Admission_Inpatient	0.267	0.442	0	1
Admission_Outpatient	0.733	0.442	0	1

N: 135,179

Figure 2.3: Descriptive Statistics of Mental Health Claims and Beneficiaries

Considering only the composition of mental health claims in Figure 2.3, only a few observations are of note. Women are over-represented slightly in mental health claims, as well as increases in the representation of minorities relative to the total population.

Additionally, within mental health claims, there is a higher proportion of inpatient claims claims to outpatient claims compared to the full sample. Most beneficiaries have, on average, 1 mental health diagnosis per claim, but there is a maximum of 5, indicated some individuals that are diagnosed with several mental health-related issues during one visit. The full distribution of diagnoses can be found in appendix figure 5.2, where we find that most of these claims are characterised as depression claims. Figure 5.2 shows the chosen set of diagnoses of interest, comprised of mainly disorders related to anxiety, depression, and stress.

3 Empirical Strategy

This section describe the empirical strategy to measure the impact of the mass shooting events on the mental health outcomes. We use a event study estimation with the following main specification:

$$y_{ct} = \alpha + \sum_{j=-1}^{J} \beta_j (Lag\, j)_{ct} + \sum_{k=1}^{K} \beta_k (Lead\, k)_{ct} + \delta_t + \lambda_c + X_{ct}^{'}\Gamma + \epsilon_{ct} \tag{3.1}$$

Where y_{ct} is the Mental Health outcome in county c, at month & year t. Lag_j is an Indicator variable wich is equal to one for an specific number of months preceding mass shooting event in county c. $Lead_k$ is an indicator variable equal to one if t is equal to a specific number of months following mass shooting event in county c. X_{ct} is a set of the county level time varying covariates relevant for mental health. We also added δ_t for time fixed effects measured at the month/year level and λ_c county fixed effects. ϵ_{ct} is the

clustered standard errors at the county level.

Our coefficients of interest are the β_k associated to each month after the shooting events. This is going to capture the average effect of being exposed to a traumatic event for the individual within the treatment group. We expect this to be positive, meaning that the mental health outcomes will be impacted in such a way that individuals will use more health services to take care of the trauma created.

While counties have dynamic and do experience changes in characteristic's over time, due to the narrow time horizon of the data, it is unlikely that changes in zip code characteristics would affect changes in mental health. We postulate that for a individual within a given county a mass shooting is a traumatic, unexpected event. Individuals cannot prepare or change mental health behavior in anticipation of the mass shooting, thus dynamic changes in mental health diagnoses over time are unaffected by the mass shooting event. Also, to have a valid difference-in-differences strategy, we suppose to see parallel trends between control and treatment. Our control group is composed of counties that did not experience mass shootings in a particular month. Using the event study approach we can verify if the parallel trend assumption is valid by observing coefficients related to the lag dummies before the event. If the coefficients are statistically different from zero, then we have evidence that the parallel trends assumption is not valid in our context.

4 Results

This section will present the results of our event study estimation. The model was estimated using the counties that experienced mass shooting events between 2008 and 2010. The expected results is a non significant set coefficients related to the lags (before the shooting) and positive and significant coefficients after the shootings.

Table 1 shows the results for the event study. In this first exercise, we aggregate months in groups. Using the mass shooting as the time zero, we grouped the leads and lags in four groups. First group of month one to month three, second group from forth to sixth month, third group from seventh to ninth month and the last one grouping all the other month after the tenth month.

The results shows that the lags are positive and statistically significant to the mental health claims outcome. This is evidence that our assumption of parallel trends does not hold and if it is true, our strategy is not able to predict a casual effect. Also, for the leads, just after the tenth month this coefficient is statistically significant. However, the direction of the effect is contra intuitive, as is negative. This would mean that the mass shooting events decrease the mental health claims in the counties affect by these events.

Figure 4.1 shows the results for an event study using a lag and lead for each year before and after the shooting. As seen before, the results have evidence that we do not have parallel trends, as we do have coefficients which are statistically significant before. For the leads, we can see the same pattern as in the table 1, a negative and statistically significant effect. Suggesting the same counter intuitive results, that the mass shooting would be negatively related to mental health claims in the counties suffering the shock.

Table 1: Event study results

	Log of Mental Health Claims
Lead (10 +)	-0.588
	(4.34)**
Lead (7-9 months)	-0.211
	(1.48)
Lead (4-6 months)	-0.226
	(1.64)
Lead (1-3 months)	-0.222
	(1.59)
Lag (1-3 months)	-0.123
	(1.18)
Lag (4-6 months)	0.197
	(2.29)*
Lag (7-9 months)	0.294
	(3.51)**
Lead (10 -)	0.328
	(3.18)**
Observations	78,803

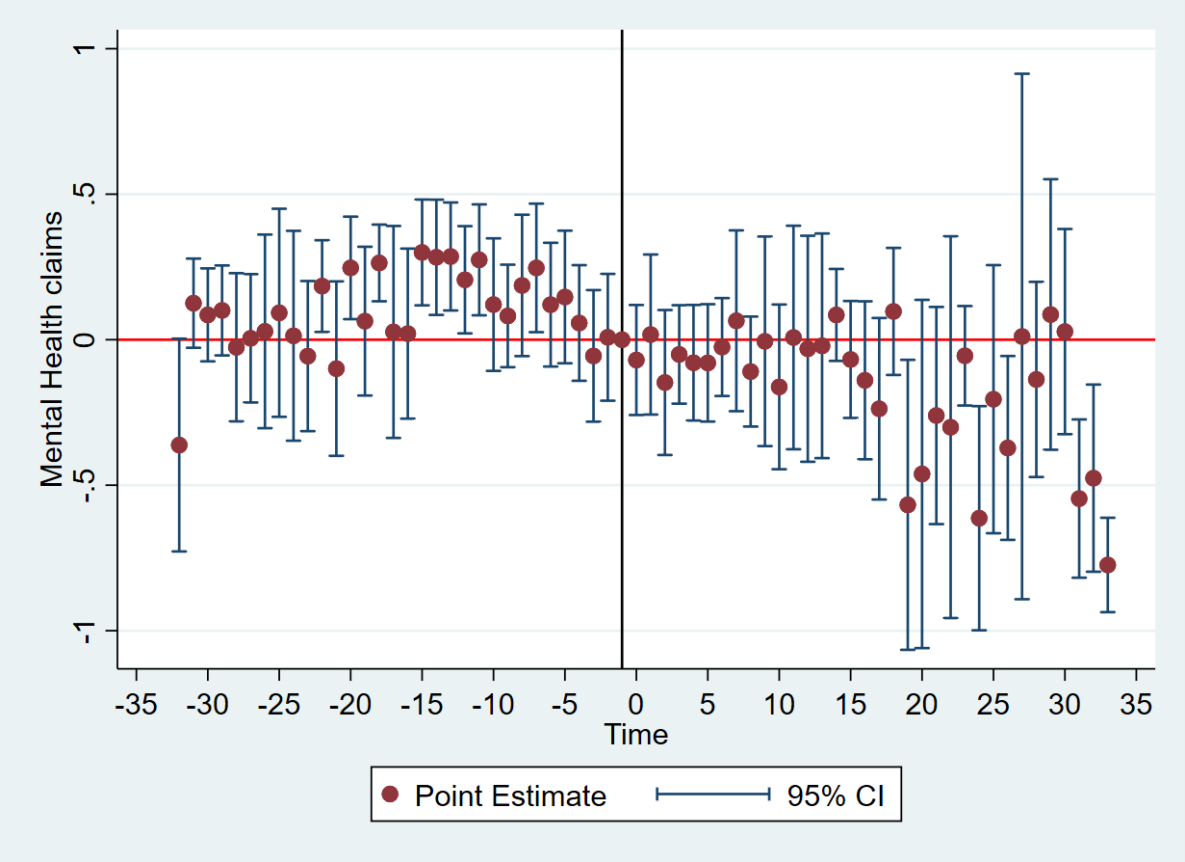

Figure 4.1: Event Study for each year

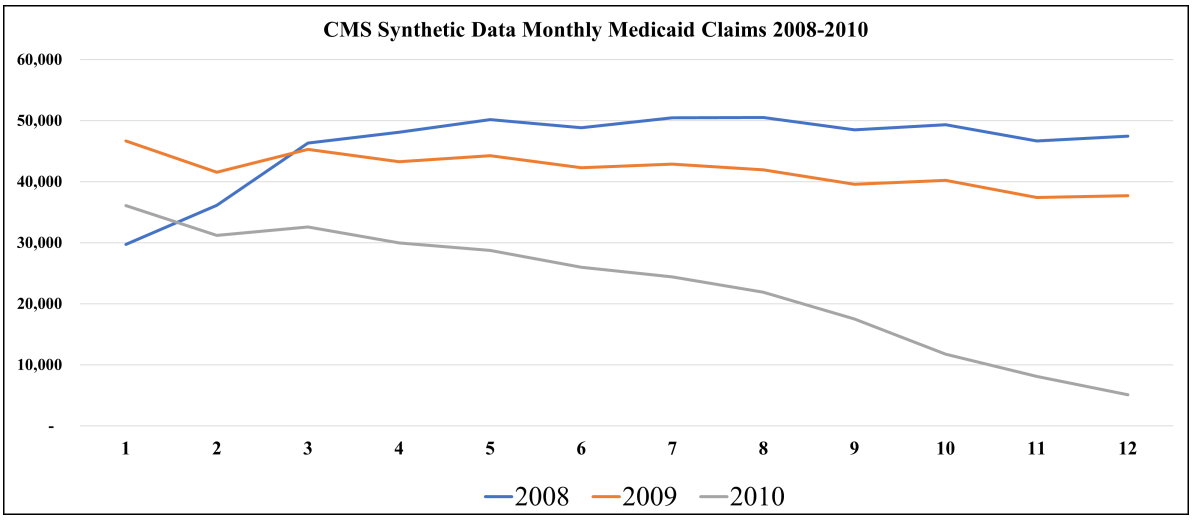

Figure 4.2: Event Study for each year

Figure 4.2 shows the synthetic observations in mental health claims for each month. We are using a sample of medicare, and the graph shows a big drop in 2010. This can be one of the reasons for our counter intuitive results. This negative trend in observations can drive our results and imply in the negative relationship seen in the leads.

5 Conclusion

Gun violence and mass shootings have long been a risk of overwhelming levels of gun ownership in the United States. Apart from the negative reprecussions of gun violence, namely deaths and injuries, traumatic events also impart a lasting mental effect on those that survive the even and the surrounding community. This paper presents the groundwork for estimating the effect of mass shootings across the US on the local population exposed to these devastating events. The use of Medicare health claims allows for the estimation

of the intent to treat effect of living in a county that has experienced a mass shooting. A difference-in-differences empirical method is implemented to compare the change in the proportion of mental health claims related to depression, anxiety, and stress, between counties that had hosted a mass shooting event, before and after the mass shooting had occurred. The effects estimated may have limited external validity, as the medicare system primarily insures retirement aged individuals. Although these limitations should be taken into account, it is conceivable that a sample of older age would only create more conservative estimates, and therefore similar or greater effects may be expected for demographics that are even more exposed to gun violence. The second-order effects of gun violence on mental health of the community is relevant to discussions on mental healthcare and gun ownership policy.

6 Appendix

ICD9 Diagnosis	Long Description
29384	Anxiety disorder in conditions classified elsewhere
29620	Major depressive affective disorder, single episode, unspecified
29621	Major depressive affective disorder, single episode, mild
29622	Major depressive affective disorder, single episode, moderate
29623	Major depressive affective disorder, single episode, severe, without mention of psychotic behavior
29624	Major depressive affective disorder, single episode, severe, specified as with psychotic behavior
29625	Major depressive affective disorder, single episode, in partial or unspecified remission
29626	Major depressive affective disorder, single episode, in full remission
29630	Major depressive affective disorder, recurrent episode, unspecified
29631	Major depressive affective disorder, recurrent episode, mild
29632	Major depressive affective disorder, recurrent episode, moderate
29633	Major depressive affective disorder, recurrent episode, severe, without mention of psychotic behavior
29634	Major depressive affective disorder, recurrent episode, severe, specified as with psychotic behavior
29635	Major depressive affective disorder, recurrent episode, in partial or unspecified remission
29636	Major depressive affective disorder, recurrent episode, in full remission
29682	Atypical depressive disorder
29690	Unspecified episodic mood disorder
29699	Other specified episodic mood disorder
2980	Depressive type psychosis
30000	Anxiety state, unspecified
30001	Panic disorder without agoraphobia
30002	Generalized anxiety disorder
30009	Other anxiety states
30010	Hysteria, unspecified
30023	Social phobia
30112	Chronic depressive personality disorder
30580	Antidepressant type abuse, unspecified
30581	Antidepressant type abuse, continuous
30582	Antidepressant type abuse, episodic
30583	Antidepressant type abuse, in remission
3080	Predominant disturbance of emotions
3083	Other acute reactions to stress
3084	Mixed disorders as reaction to stress
3089	Unspecified acute reaction to stress
3090	Adjustment disorder with depressed mood
3091	Prolonged depressive reaction
30921	Separation anxiety disorder
30924	Adjustment disorder with anxiety
30928	Adjustment disorder with mixed anxiety and depressed mood
30981	Posttraumatic stress disorder
311	Depressive disorder, not elsewhere classified
96900	Poisoning by antidepressant, unspecified
96904	Poisoning by tetracyclic antidepressants
96905	Poisoning by tricyclic antidepressants
96909	Poisoning by other antidepressants
E8540	Accidental poisoning by antidepressants
E9390	Antidepressants causing adverse effects in therapeutic use
V6289	Other psychological or physical stress, not elsewhere classified
V790	Screening for depression

Figure 6.1: Description of ICD9 Diagnosis Codes

Statistic	Mean	St. Dev.	Min	Max
Mental Health Diagnoses per Claim	0.067	0.369	0	6
Mental Health Claims	0.032	0.177	0	1
ICD9 Diagnosis Code				
29384	0.0001	0.012	0	1
29620	0.001	0.033	0	1
29621	0.0002	0.013	0	1
29622	0.0002	0.016	0	1
29623	0.0003	0.016	0	1
29624	0.0002	0.016	0	1
29625	0.0002	0.013	0	1
29626	0.0002	0.013	0	1
29630	0.001	0.027	0	1
29631	0.0002	0.015	0	1
29632	0.001	0.023	0	1
29633	0.001	0.027	0	1
29634	0.0004	0.021	0	1
29635	0.0002	0.015	0	1
29636	0.0002	0.014	0	1
29682	0.0002	0.014	0	1
29690	0.001	0.026	0	1
29699	0.0002	0.015	0	1
2980	0.0001	0.010	0	1
30000	0.009	0.095	0	1
30001	0.001	0.026	0	1
30002	0.001	0.032	0	1
30009	0.0002	0.013	0	1
30010	0.0001	0.009	0	1
30023	0.0001	0.011	0	1
30112	0.00002	0.004	0	1
30580	0.00001	0.003	0	1
30581	0.00001	0.003	0	1
30582	0.00000	0.002	0	1
30583	0.00001	0.002	0	1
3080	0.0002	0.012	0	1
3083	0.0001	0.011	0	1
3084	0.0001	0.009	0	1
3089	0.0002	0.013	0	1
3090	0.0003	0.017	0	1
3091	0.0001	0.008	0	1
30921	0.00000	0.002	0	1
30924	0.0001	0.008	0	1
30928	0.0001	0.012	0	1
30981	0.001	0.030	0	1
311	0.014	0.119	0	1
96900	0.00000	0.002	0	1
96904	0.00000	0.002	0	1
96905	0.00001	0.003	0	1
96909	0.00001	0.004	0	1
E8540	0.00001	0.003	0	1
E9390	0.00004	0.006	0	1
V6289	0.0001	0.010	0	1
V790	0.0001	0.009	0	1
N	**4,198,855**			

Figure 6.2: Summary of Diagnoses Claims

References

[1] Antonis Katsiyannis, Denise K Whitford, and Robin Parks Ennis. “Historical examination of United States intentional mass school shootings in the 20th and 21st centuries: Implications for students, schools, and society”. In: *Journal of Child and Family Studies* 27.8 (2018), pp. 2562–2573.

[2] Prashant Bharadwaj et al. “Surviving a mass shooting”. In: *Journal of Public Economics* 201 (2021), p. 104469.

[3] James N Meindl and Jonathan W Ivy. “Mass shootings: The role of the media in promoting generalized imitation”. In: *American journal of public health* 107.3 (2017), pp. 368–370.

[4] Cristina Mitchell. *Mental Health Problems are the Leading Cause of Disability Worldwide, say experts at Paho Directing Council Side Event*. Oct. 2019. URL: https://www3.paho.org/hq/index.php?option=com_content&view=article&id=15481.

[5] National Alliance on Mental Illness. *Mental Health by the Numbers*. Feb. 2022.

[6] Mark Follman et al. “The true cost of gun violence in America”. In: (2018).

[7] Dongyoung Kim and Young-I1 Albert Kim. “Mental health cost of terrorism: Study of the Charlie Hebdo attack in Paris”. In: *Health economics* 27.1 (2018), e1–e14.

[8] Marika Cabral et al. *Trauma at School: The Impacts of Shootings on Students’ Human Capital and Economic Outcomes*. Tech. rep. National Bureau of Economic Research, 2021.

[9] Rosanna Smart. “Mass Shootings: Definitions and Trends”. In: *Gun Policy in America* (2018).