The Local Effect of School Shootings on Hospital Utilization in California

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Abstract: School shootings are devastating events with far-reaching impacts on communities. While much research has focused on the immediate loss of life and psychological trauma, the effects on healthcare systems remain underexplored. This study examines the impact of school shootings on hospitalization and in-hospital mortality in California between 2005 and 2018. We leverage administrative hospital discharge data linked to geocoded school shooting incidents, applying a difference-in-differences methodology to quantify changes in healthcare utilization within a 3-mile radius of fatal school shootings. Our findings reveal a 22 percent increase in hospital utilization in areas surrounding these events. We also observe a significant rise in in-hospital mortality rates, underscoring the severe and long-term consequences of such traumatic events. The results highlight the hidden healthcare burdens that school shootings impose on already strained hospital systems and affected communities. This study contributes to the broader literature on gun violence by offering a novel perspective on the indirect costs of school shootings. It highlights the need for comprehensive public health interventions and policies that address both the direct and indirect impacts of gun violence. By examining how these tragedies affect local healthcare systems, the research provides critical insights for policymakers, healthcare providers, and community leaders striving to mitigate the widespread consequences of school shootings.

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1. Introduction

School shootings seemingly have become part of everyday life in the United States. Based on the U.S. Department of Education report, in the 2020-2021 school year, 93 school shootings with casualties occurred—one incident every other day in a school year—suggesting that these incidents have tripled in only two decades (Irwin et al., 2022).[3] Although the vast majority of deaths by firearms still occur outside of schools, public attention seems uniquely drawn to violent events that happen at schools. The level of detailed accounts to which the public is subjected is comparatively unique among violent events (Burns & Crawford, 1999). Media, both television and social, also helps to foster an exaggerated reaction to school shootings (Muschert, 2007; Schildkraut et al., 2015). The fear and anxiety, which is particularly felt in the communities where the event takes place (Curry, 2003; Norris & Stevens, 2007; Soni & Tekin, 2023), exceeds that which accompanies other acts of violence.

Shootings at schools have been shown to have long-term and profound impacts on the students (Rossin-Slater et al., 2020; Vasan et al., 2021) who survive them. There is also limited but convincing evidence of the impact on nearby communities (Bharadwaj et al., 2021; Soni & Tekin, 2023). However, little is known about the local effect of these events on the health of the general public in close proximity to schools and their utilization of healthcare services in the aftermath of school shootings.

In this paper, we test whether the fear, anxiety, and distress that grips communities where school shootings take place have observable effects on hospitalizations and mortality. We focus on shootings in California between 2005-2018. We investigate these effects by geocoding the

[3] These statistics are based on the definition provided by the K-12 School Shooting Database (K-12 SSDB), which takes into account "incidents in which a gun is brandished or fired on school property or a bullet hits school property for any reason, regardless of the number of victims, time of day, day of the week, or reason."

precise location of the targeted schools and all hospitals, calculating the distance between the incident locations and hospitals, and comparing the hospitalizations in the hospitals near the targeted schools (within 3 miles) with those further away before and after the school shootings. Our main finding is that inpatient hospitalizations increase following fatal school shootings. There are also effects on in-hospital mortality, suggesting these are significant episodes.

To verify the robustness of our findings, we make use of recent advances in the difference-in-differences literature, which highlight that estimates using conventional methods are potentially not robust to staggered interventions due to the violation of the treatment heterogeneity assumption (Callaway & Sant'Anna, 2021; De Chaisemartin & D'Haultfoeuille, 2020; Gardner, 2022; Goodman-Bacon, 2021; Sun & Abraham, 2021). To account for this issue, we rely on the two-stage difference-in-differences approach proposed by (Gardner, 2022), which provides a transparent solution.

The paper adds to the small but growing literature on behavioral responses to school shootings. The psychological impact of school shootings on communities is real, and the need to seek professional help when they occur has been well-documented (Miquelon et al., 2014). Following the results of the paper, we can add hospitalizations and in-hospital mortality to the list of medium-term outcomes impacted by these traumatic events.

Section 2 provides some background on school shooting with attention to related recent papers in the literature. Section 3 presents our data and methodology. Section 4 presents the results, and section 5 concludes the paper.

2. Background on School Shootings and Evidence of Their Effects

The United States is facing a recent surge in gun violence. In 2020, there was a particularly large increase in murders and suicides by firearm. This continued into 2021, which stands as the deadliest year on record. Mass shootings, which are defined in a Department of Justice report (Guns, 2013; Mayors Against Illegal Guns, 2013; U.S. DOJ, 2013) as a shooting in which there are 4 or more victims, also reached an all-time high in 2021. Firearm-caused deaths of those under 12 peaked in 2021 and teen gun deaths peaked reached a high in 2022. In 2022, the latest year with complete data, 48,830 people died from gun-related injuries in the U.S. The rate of gun deaths in the U.S. far surpasses any other industrialized country and has had observable effects on the economy (Irvin-Erickson et al., 2017), with mass shootings in particular taking a unique impact (Brodeur & Yousaf, 2022).

The impact of gun violence in general on children has received recent academic attention and helps to guide our approach in this paper. Gershenson and Tekin (2018) investigate the effects of the sniper attacks in the DC area that took place during 2002. They utilized geographic proximity to the attacks to assess the relative effects on proficiency among Virginia school students. They find a small but significant decline in test scores among these students, but the effects fade over time. This is similar to the work of Sharkey (2010) and Sharkey et al. (2014) who estimate similarly sized declines in test scores of students within close proximity to homicides in Chicago and New York. This reinforces the idea that trauma has an impact on the communities affected, particularly the development of children, even if the individuals themselves were not directly impacted. This has also been shown to be the case with acts of terror like the September 11 attacks (Auger et al., 2004; Otto et al., 2007) and natural disasters like Hurricane Katrina (Scott et al., 2014).

More recently, Ang (2021) used precise location data of police shootings in Los Angeles to assess the impact on students. He finds a significant effect on African American students in terms of their GPA and high school completion. They are less likely to attend college, and their emotional well-being is affected. The effect is driven entirely by minority students are most affected by the shooting of their peers.

This spillover of effects onto young survivors is also consistent with evidence from a major shooting event in Norway and three major school shootings with high fatalities in the US (Levine & McKnight, 2024). In 2011, a politically-motivated shooting took place at a summer camp being attended by school children on the island of Utoya. This was not a school shooting *per se*, but the age of the children makes it relevant. There were 69 children whose lives were lost, 66 were injured, and 585 survived without physical injury during the attacks. Bharadwaj et al. (2021) found that the young survivors of the event, aged 14-15, achieved half a standard deviation lower test scores in middle school compared to a control group of students not on the island. The high-school aged survivors were less likely to complete high school. All children reported more medical visits and increased psychiatric diagnoses. (Dyb et al., 2014) and (Stene & Dyb, 2015) documented significantly higher rates of health care utilization post attacks among survivors. The attacks had effects beyond just the students. Although parents of survivors did not experience changes in labor market outcomes, they also utilized health care services more (Bharadwaj et al., 2021). Other work on the parents of the Utoya survivors suggests there were substantially higher rates of post-traumatic stress symptoms than the general population, as well as higher rates of anxiety and depression (Thoresen et al., 2016).

There is large public interest in such events when they occur. There is also growing evidence that those who were present at such shootings face long-term, profound effects,

including both academic and health outcomes. Levine and McKnight (2021) examine the consequences of being exposed to school shootings on health and academic achievement, with the latter measured by test scores and absenteeism. They conduct their analysis on national data, with additional analyses using Connecticut data to assess the effects of the Sandy Hook shootings. They find adverse effects. A more recent paper by the same authors finds that there are increases in deaths among survivors, particularly from substance use and suicides among males (Levine & McKnight, 2024).

Cabral et al. (2021) offer the most complete set of estimates of the effects of school shootings on students to date. They utilize administrative records from Texas schools to analyze the aftermath of shootings that took place at schools within the state from 1995-2016. In the short run, affected students experience a significant increase in absenteeism and a doubling of the probability of repeating a grade. Following the aftermath of a smaller sample of shootings, they observe substantial long-term effects, including lower likelihoods of graduating high school, attending college, and significantly lower earnings in the labor force once they enter.

Studies discussed above mostly evaluate the effect of school shootings on educational outcomes among school-aged children who were likely targeted by these traumatic events. However, as Soni and Tekin (2023) show in their analysis, they may affect the broader population in the community, especially their health outcomes. Gujral et al. (2023) study the effect of school shootings in California between 2005 and 2011 and find an increase in ED visits linked to stress increase by 14% in zip-codes within a 5-mile radius of the zip-code in which shootings take place. Like Gujral et al. (2023), our paper aims to extend the analysis of school shootings to the community at large but for a more complete set of hospitalizations.

There is ample evidence that the impact of school shootings is felt in the community, particularly for those living close to the schools. Rossin-Slater et al. (2020) estimate whether anti-depressant use increases following school shootings. Similar to our approach, they estimate whether there are changes in prescriptions by providers 0-5 miles away from the shootings compared with those a bit farther away. They find significant increases among young people, with concentrated effects in areas where providers are more prone to use pharmaceuticals vs. behavioral interventions. The increase may be because of those exposed to a shooting at their school but might also be influenced by the general effects of the shootings on mental health in the community.

Regarding mass shootings in general, not necessarily in schools, Brodeur and Yousaf (2022) and Soni and Tekin (2023) show significant mental health effects among community members, and Brodeur and Yousaf (2022) study how it spills over into their productivity at work and hurts the local economy. As the national media amplifies coverage of the events, the effects worsen. Regarding school shootings specifically, Muñoz-Morales and Singh (2023) find a significant erosion of property values driven by lower school attendance stemming from traumatic community events. This effect was similar to other evidence on shootings and attendance (Abouk & Adams, 2013) and shootings.

We contributes to this literature by identifying changes in several health-related outcomes near where school shootings take place. In addition to the mental health of those directly exposed to the shootings, research has suggested mental health effects might be expected among those living in the community who also feel the anxiety and depression that follow the shootings (Lowe & Galea, 2017). It is well-known that traumatic events, of which shootings in a community are usually considered, are followed by increased somatic symptoms (Boscarino,

2004; Gupta, 2013; Lauterbach et al., 2005; McFarlane et al., 1994; Spitzer et al., 2009). These include nervous, cardiovascular, respiratory, musculoskeletal, and gastrointestinal symptoms. Therefore, the effects of school shootings—as traumatic events—are not only limited to mental health conditions but also extend to physical health, affecting several organs related to the immune system. For that reason, we will first investigate the effect of these events on overall ED, as well as inpatient visits. We then document the causes of hospitalizations among these community members.

3. Data and Methods

3.1 Data on School Shootings

We utilize detailed data on school shootings from the K-12 School Shooting Database (K-12 SSDB) (Riedman & O'Neill, 2018). The database contains comprehensive information on several aspects of an incident, such as whether a gun is brandished, fired, or a bullet hits school property. It also includes information about the time of the day and the day of the week when an incident occurred and the number of injuries and deaths. The database has been used in several other studies (Cabral et al., 2021; Deb & Gangaram, 2024).

We consider only those incidents that occurred on the school property, during the regular school hours and days, and involved a gun being fired. Based on these criteria, we identified 36 school shootings during the 2005-2018 period in California. Nine of these shootings were fatal, and the rest were non-fatal shootings.

We will begin by considering hospitals within a 10-mile radius of a targeted school as those with patients who are potentially exposed to the shooting, either because they attended the school or, more likely, are members of the community at large that were indirectly affected.

Based on this characterization, during our sample period, 157 acute care hospitals accepted patients potentially exposed to a school shooting in their community. Of these, 68 hospitals were in areas with a fatal shooting, and 140 hospitals were in areas with a non-fatal shooting. Also, some hospitals accepted patients who were exposed to these incidents more than once. For example, 58 hospitals were exposed once, 47 hospitals were exposed two times, 21 hospitals three times, 25 hospitals four times, six hospitals five times, and one hospital six times.

3.2 Hospital Utilization

We use the 2005-2018 universe of patient-level administrative data from California's Department of Health Care and Information (HCAI). Specifically, we utilize inpatient discharges (IP) in all California-licensed acute-care hospitals that were continuously operational during our sample period. Out of these 307 hospitals, 134 were exposed to any school shootings, 54 were exposed to fatal shootings, and 120 were exposed to non-fatal shootings in schools within a 10-mile radius. The IP dataset contains detailed information about the patient sociodemographic background, such as date of birth, race, gender, and county of residence. Also, the source of payment (Medicare, Medicaid, private coverage, self-pay, and others), admission date for IP visits, and length of stay for IP visits are known. The data also include information about the hospitals in which patients receive care, such as their physical address, number of beds available, number of operating rooms, number of intensive care units (ICU), and coronary care units (CCU).

In our main analysis, we aggregate both inpatient admissions and in-hospital deaths to the facility-year-month level, where year-month refers to the year-month of admission and not the

discharge. Finally, we geocode hospitals and the targeted school locations and calculate the distance between them. We consider a hospital treated if it is located within a 10-mile radius of the targeted school.

We control for a series of factors at the hospital and county levels. We control for the number of hospital beds and operating rooms, whether the hospital is a teaching hospital, and the number of ICUs and CCUs. These factors are not necessarily constant during our sample period as the capacity of the facilities may change. We also control for the county population level. Finally, to capture general violence in the area, we also add a binary variable for the occurrence of any mass shootings within the immediate geographic area (a three-mile radius in the main estimations). Our main analysis includes 307 hospitals that were continuously operational throughout the sample period providing 51,576 observations at the facility-year-month level. However, we report results from the full sample of facilities, which includes those that were opened or closed during the sample period in SI Appendix Table S3.

3.3. Methodology

We use a difference-in-differences (DD) linear regression model to estimate the effect of school shootings on hospital inpatient admissions and in-hospital deaths. In particular, we start by estimating the following model:

$$Y_{ht} = \alpha + \beta_1 SS_{ht} + X_{ht}\beta_2 + Z_{ct}\beta_3 + \lambda_h + \tau_t + \varepsilon_{ht} \qquad (1)$$

In model (1), Y_{ht} corresponds to the number of admissions (or deaths) to (in) hospital *h* at the time (year-month) *t*. The variable SS_{ht} is a binary variable equal to one if any school shooting (fatal or non-fatal) occurred in a 10-mile radius of hospital *h* at time *t*, and the main parameter of

interest, β_1, captures its effect. X_{ht} and Z_{ct} control for hospital-level and county-level time-varying factors discussed in the previous section. We cluster the standard errors at the hospital level, taking into account the non-independence of observations within hospitals over time (Bertrand et al., 2004). We also weight the estimates by number of hospital beds, which accounts for the greater variance in the smaller hospitals. We check whether our results are robust to not weighting as well, which they are.

We then separate the effect of fatal and non-fatal shootings by estimating the following regression model:

$$Y_{ht} = \alpha + \beta_{1,1} SS_{fatal_{ht}} + \beta_{1,2} SS_{nonfatal_{ht}} + X_{ht}\beta_2 + Z_{ct}\beta_3 + \lambda_h + \tau_t + \varepsilon_{ht} (2)$$

In this specification, parameter $\beta_{1,1}$ provides us with the estimated effect of fatal shootings and $\beta_{1,2}$ reports the effect of non-fatal school shootings.

Recent developments in the DD literature suggest that the conventional DD estimates with more than two groups and two time periods may be biased due the inclusion of negative weights in the estimation of the average treatment effect because of utilizing '*forbidden comparison*' groups (Goodman-Bacon, 2021) and proposes estimations robust to the treatment heterogeneity assumption (Callaway & Sant'Anna, 2021; De Chaisemartin & D'Haultfoeuille, 2020; Gardner, 2022; Sun & Abraham, 2021).

We use the two-stage DD model proposed in Gardner (2022) to address this issue. In the first stage, we regress the outcome variable on hospital and time fixed effects and other

explanatory variables for the period before school shootings took place, calculate the residuals and subtract them from the outcome variable. In the second stage, the residualized outcome is regressed on all write-hand-side variables listed on Model (1) for the whole study period. Finally, a General Method of Moment (GMM) estimator is used to correct the standard errors in the first stage.

To empirically test for the internal validity of our DD model, we run a series of event study models in which we replace the main policy variable, SS_{ht}, with three leads and six lags, capturing the effect of shootings three years and before, two, and one year before the shootings happen and in the year in which the incident occurs (first 12 months), two, three, four, five, and six years and more after the shootings take place. This is done by binning together every 12 months relative to shootings to create years relative to those events.

4. Results

4.1.Descriptive statistics

Table 1 reports the descriptive statistics for two groups of hospitals: 1) hospitals not exposed to school shootings, 'untreated', and 2) hospitals exposed to school shootings where exposure is defined as being within a 10-mile radius of a school in which shootings occurred, before the exposure, 'treated.' The monthly average of all inpatient visits and in-hospital deaths in untreated hospitals is lower than the treated hospitals before the exposure. These differences may be in part attributed to the hospital size. As shown, the average total of hospital beds is higher for the treated group compared to the untreated hospitals. In-hospital deaths show patterns similar to those for inpatient visits, although these incidents are less frequent. Treated hospitals have more

beds, CCUs, and ICUs, while there is not much difference in the number of operating rooms. Treated hospitals are also more likely to be teaching hospitals. It is also very unlikely that untreated and treated hospitals to be located within a three-mile radius of a mass shooting.

4.2.Regression Results

4.2.1. Identifying the affected radius of hospitals

So far, we considered hospitals within a 10-mile radius of targeted schools as those exposed to school shooting incidents. However, one of the challenges in studying the effect of traumatic events such as school shootings is that there is no clear 'treated 'vs. 'control' group. Therefore, to overcome this challenge, we first investigate the effect of these events on hospital admissions and in-hospital deaths by distance between the targeted school and the hospitals. Figure 2 illustrates the estimated effects of shootings by miles from the hospital. The first observation is that nonfatal shootings have limited impact on the studied outcomes based on distance from the facility.

Fatal shootings are clearly different. In panel A, the effects are largest if the shooting happened within 2 or 3 miles of the hospital. They remain positive out to 10 miles from the shooting but are smaller and less significant. For in-hospital deaths, the effects peak again at hospitals within a 3-mile radius of the shooting but appear positive out to a 10-mile radius. Based on the results presented above, we consider fatal school shootings within the 3-mile radiuses of an acute care hospital as the criteria to define treatment for further analyses on the heterogeneities of the effects.

4.2.2. Regression results for hospitals within a 3-mile radius of fatal shootings

Figure 3 illustrates the event study graphs for the effect of fatal shootings on inpatient visits and in-hospital deaths. These results provide evidence about the validity of the DD methodology by flexibly estimating the temporal effect of shootings on the outcome of interest for months leading up to the occurrence of a shooting incident and those post-shootings. Panel A shows that for the three years prior to the fatal shootings, there were no differences in inpatient admissions in treated vs. untreated hospitals. This supports the assumption that there were no significant pre-treatment trends that threaten the validity of our interpretation of the results. Panel B also confirms no differences in the pre-treatment trends in treated and non-treated hospitals with regard to in-hospital deaths. The dynamic effects of the fatal shootings are reflected in the years following the shooting (1 through 6+). The jump in monthly inpatient visits occurs immediately following the fatal shootings, but the effects are small relative to the increases over time as the stress effects of the shootings take their toll. The estimates persist well into the future. A similar pattern is observed for in-hospital deaths, with a one-year lag.

SI Appendix Table S1 shows the effects of shootings in schools within a 3-mile radius of hospitals on our outcomes of interest. The magnitude of the effect of fatal shootings in column (2), where all controls are included in the specification, suggests a 22% increase in inpatient admissions that is significant at the .05 level. In our analytical sample, five hospitals were exposed to fatal shootings in schools within their 3-mile radius. Therefore, clustering standard errors at the hospital level may result in the underestimation of standard errors of the corresponding DID coefficient. To check the robustness of our estimates to the few treated cluster issue we utilize the randomization inference procedure proposed in SI Appendix Table S2 Although inpatient deaths are much more rare, there is also an increase in those, although

statistically insignificant, with an average of two more deaths in hospitals close to a shooting each quarter. We next engage in a series of additional tests to assess the validity of the results.

4.3.4 Robustness checks and sensitivity analysis of main specifications

We made several choices in our estimations that we believe best identified the effects of shootings. Appendix Table S3 repeats the main estimates from SI Appendix Table S2 in the top row and also reports a series of additional sensitivity analyses. In row 2, we relax the assumptions that a hospital must report in each period to be included in our balanced sample or remain open. The estimates are close to those from the main analysis. In our primary analysis, we use the facility-level monthly inpatient admissions as the outcome. Row 3 presents results based on the rate of admissions (admissions per 1,000,000 county population). Again, the results are similar to those found based on the number of inpatient visits presented in SI Appendix Table S1.

Row 4 reports the results with the outcome variable logged, which confirms similar magnitudes of the main effects. In addition, the nature of the outcome variables used in the analysis, which is a count variable, suggests a Poisson regression might be appropriate. Row 5 shows smaller effects on inpatient admissions which might be related to the fact that Poisson regression models, are not robust to treatment heterogeneity assumption.

Finally, the main estimations used hospitals that are beyond a 3-mile radius from a shooting as the control hospitals. This stemmed from our prior that the hospitals within 3 miles might include those patients most affected by the shootings. Since Figure 2 shows that those 5 miles away are not affected, it might actually be sensible to have hospitals 5-10 miles away as

control hospitals. These might be more similar based on regional proximity. Results suggest that the results do not materially change with these other hospitals as the "untreated hospitals."

Next, we present the event study results for fatal shootings by sex, race, and age in SI Appendix Fig. S1-S2. The results by sex suggest a less precisely estimated effect among men, while the effect of fatal shootings on women is more significant and long-term. However, the magnitude of the increase in inpatient admissions for men is bigger compared to women in relative terms (54% vs. 20%). Investigating the effect of fatal shootings by race suggests that an increase in inpatient admissions is observed among both Whites and non-Whites, with the former experiencing a bigger relative increase (64% vs. 21%).

SI Appendix Fig. S2 reports the effect of fatal school shootings by age. These results suggest that the observed increases in hospital inpatient admissions are mainly driven by middle-age groups and the elderly, those ages 25-44 and older. In addition, admissions among school-aged children increases up to three years post-fatal shootings and the goes back to zero. There is also little evidence of the effect of fatal shootings on children under five. We do not report the subgroup analysis for in-hospital deaths, as this analysis reduces the outcome frequency and increases the volatility.

We next assess the effects of fatal shootings by Major Diagnostic Categories (MDC), which helps us explore the effect by health conditions, as school shootings may mainly affect conditions triggered by stress and anxiety (Boscarino, 2004; Gupta, 2013; Lauterbach et al., 2005; McFarlane et al., 1994; Spitzer et al., 2009). The MDCs are formed by dividing principal diagnoses on admission into several categories, each of which corresponds to a particular organ and the corresponding medical specialty. We study the effect of fatal shootings by MDC, providing insights whether the increases in inpatient visits are linked to increases in conditions

linked to traumatic events. SI Appendix Fig. S3 illustrates the effect of fatal shootings by 25 MDCs and suggests that the increases in hospitalizations were driven by conditions related to mental health and substance abuse, which other work has linked to traumatic events (SAMHSA 2014), including school shootings. Other large and near significant effects are found regarding the digestive system, respiratory system, and circulatory system. Traumatic events have shown to affect the functioning of these systems (Luft et al., 2012; Stam et al., 1997; Sumner et al., 2015). For other diagnosis, such as those related to childbirth or infectious disease, there is no correlation detected. These are also unrelated to trauma resulting from a traumatic event. We note, however, that these results are presented for descriptive purposes and open to alternative explanations.

5. Conclusion

We show that school shootings, especially those that are fatal, have a long-lasting local impact on IP visits and in-hospital deaths, increasing these measures by about 22 percent in hospitals close to the targeted schools. This contributes to the growing literature on the far-reaching effects of school shootings, not just on those directly affected but the nearby communities as well. The attention paid to these events grip communities with anxiety and fear, and they, in turn, affect the local economy through effects on a wide range of outcomes, including residents' mental health and housing prices (Brodeur & Yousaf, 2022).

In order to put these estimated effects in perspective, we compare them with the estimated effect of a series of interventions affecting hospital utilization. Friedman et al. (2001) investigated the pollution reduction effect of promoting public transportation in Georgia after the

1996 Olympic games and found a 19.1 percent decline in asthma admissions in metropolitan Atlanta hospitals. Danagoulian et al. (2022) study the effect of the 2014 water contamination in Flint, Michigan, and find a 4-11 percent increase in the share of Medicaid enrollees with office visits in the first two quarters after the exposure to contaminated water.

Our study has some limitations. Although the restricted-use data from HCAI and our school shooting database allow us to geocode the location of hospitals and schools, patients' home addresses are not available in the data. Therefore, the distance between the patient's location and the targeted school could not be calculated. To tackle this issue, we restrict the analysis sample to patients living in zip codes within a 3-mile radius of hospitals, as the zip code of residence is identified in our data.

The slow progress in adopting gun-control policies in the politically divided government does not seem sufficient to address the gun violence crisis in the long run in the U.S. Therefore, more efforts are needed to counter the upward trends in such incidents. One such effort is to highlight the hidden costs associated with these traumatic events by investigating their unintended consequences. The present study aims to analyze the burden of school shootings on the healthcare system to underscore their costs.

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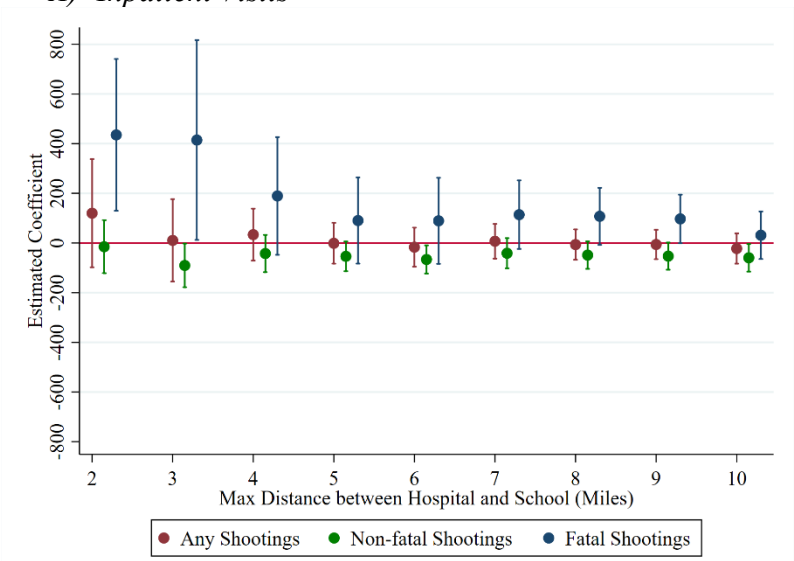
Figure 1 Location of Schools Targeted by Shootings and Hospitals



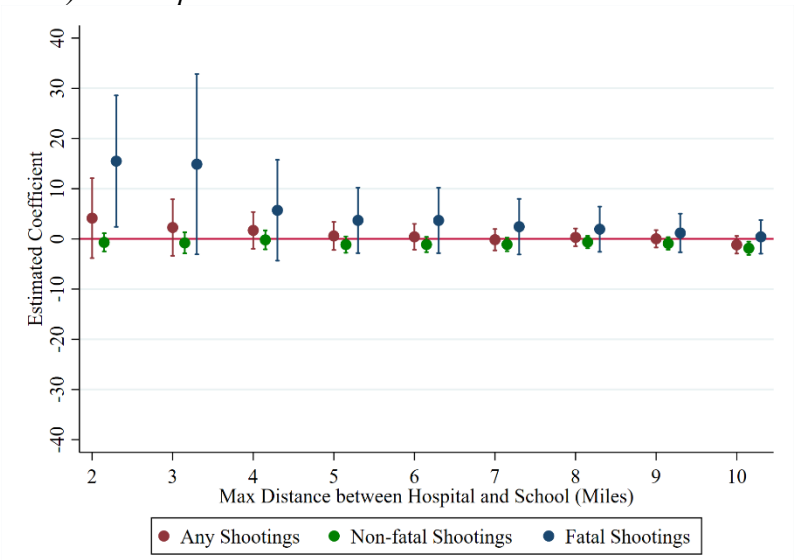
Source: SSDB and HCAI

Figure 2 Effect of School Shootings by the Distance between School and Hospitals

A) Inpatient Visits



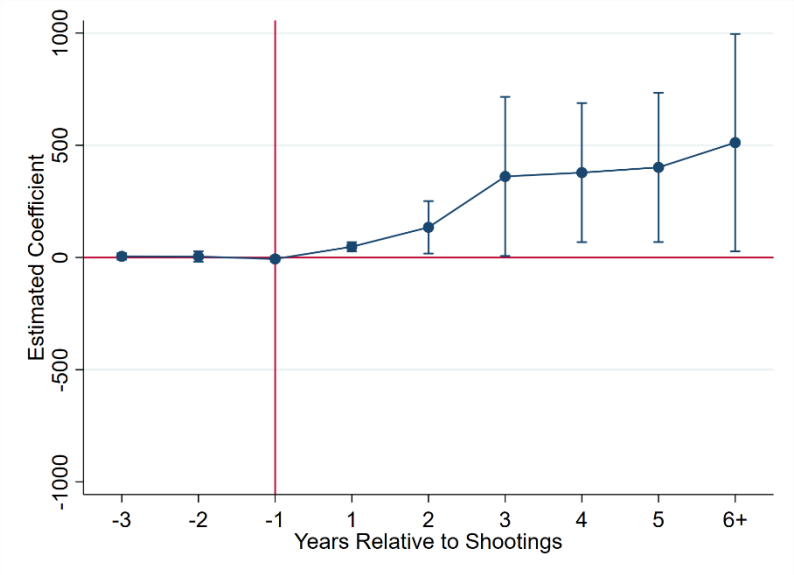
B) In-hospital Deaths



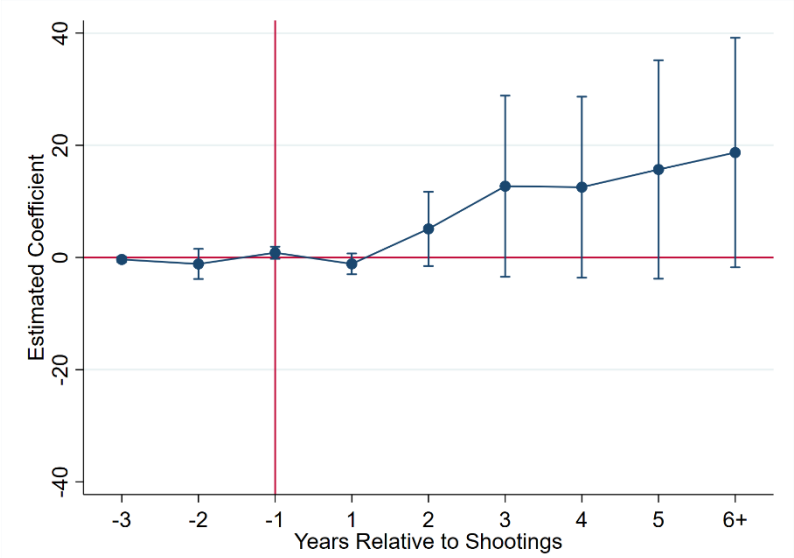
Notes: Each figure reports the result from multiple two-stage DID regressions weighted by total hospital beds. We consider two-to-ten-mile radiuses between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. All outcomes are at the facility-month level. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level.

Figure 3 Event Study Results for the Effect of Fatal Shootings on Inpatient Visits and In-hospital Deaths

A) Inpatient Visits



B) In-hospital Deaths



Notes: Each figure reports the result from a two-stage DID regression weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level.

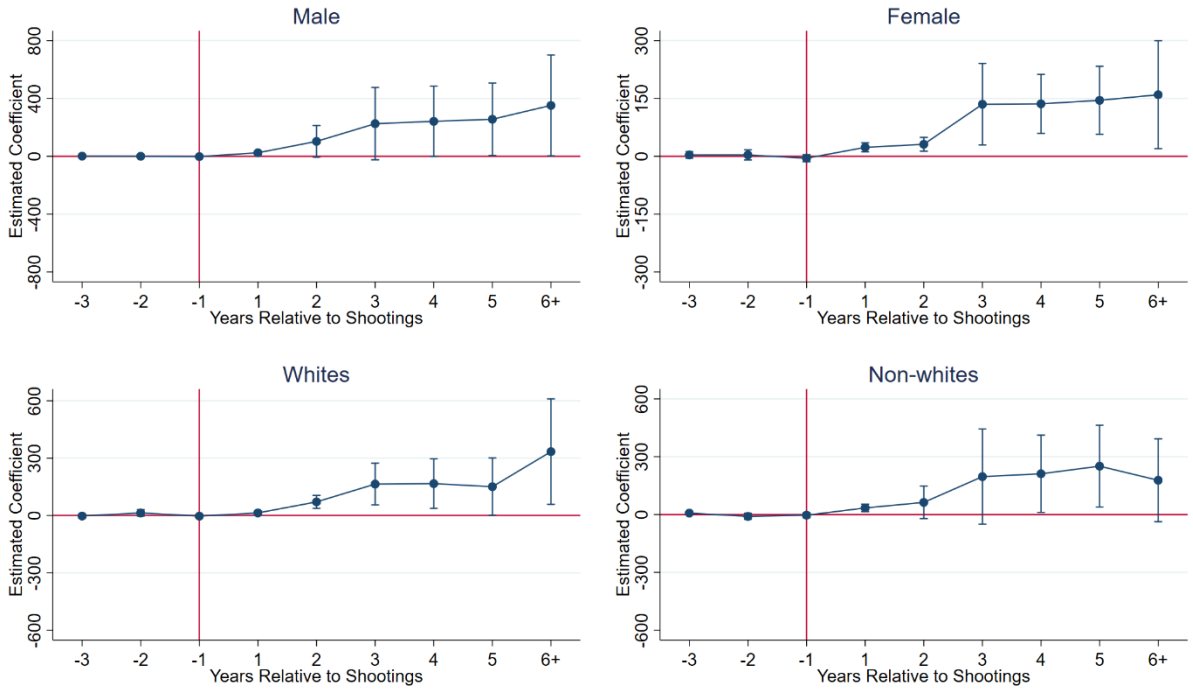
Table 1 Descriptive Statistics

Variables	(1) Untreated Hospitals (S.D.)	(2) Treated Hospitals, Before (S.D.)
Inpatient Visits, All	745.90	994.67
	(669.14)	(728.63)
In-hospital Deaths, All	15.36	21.16
	(15.25)	(15.71)
Number of Beds	190.96	258.65
	(141.51)	(153.74)
Number of Operating Rooms	7.56	8.72
	(6.08)	(5.94)
Teaching Hospital	0.05	0.07
	(0.22)	(0.25)
CCUs	3.12	5.17
	(5.62)	(6.05)
ICUs	15.21	17.12
	(14.91)	(16.11)
County Population (in millions)	15.82	4.51
	(18.50)	(4.22)
Mass Shootings in a Three-mile Radius	0.002	0.000
	(0.045)	(0.000)
Observations	29,064	4,828

Note: Hospitals within a 10-mile radius of a school in which shootings occurred are considered treated. Numbers in parentheses are standard deviations.

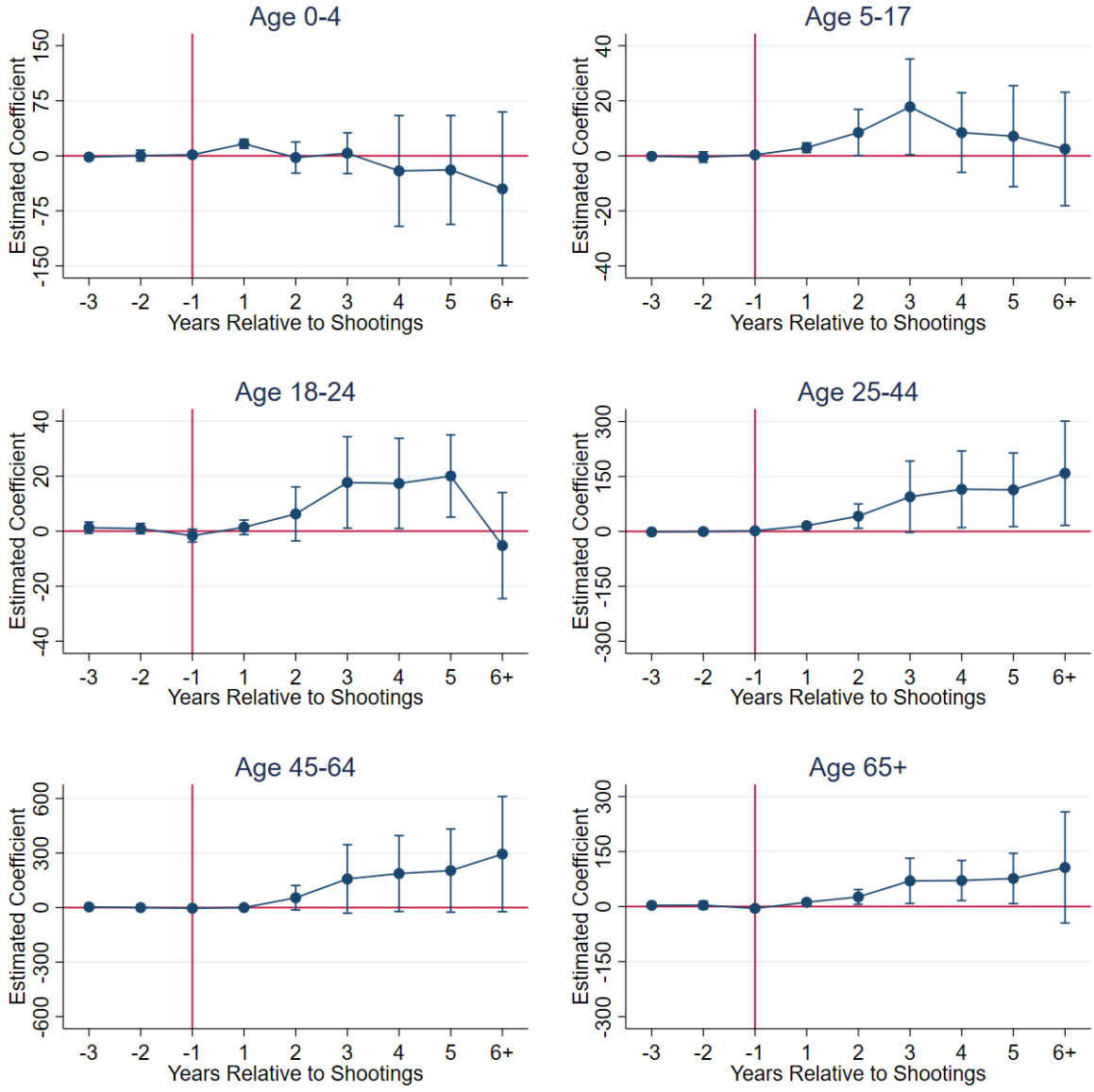
Supplemental Information

Figure S1 Event Study Results for the Effect of Fatal Shootings on Inpatient Visits by Sex and Race



Notes: Each figure reports the result from a two-stage DID regression weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level.

Figure S2 Event Study Results for the Effect of Fatal Shootings on Inpatient Admissions by Age



Notes: Each figure reports the result from a two-stage DID regression weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level.

Figure S3 Effect of Fatal School Shootings on Inpatient Visits

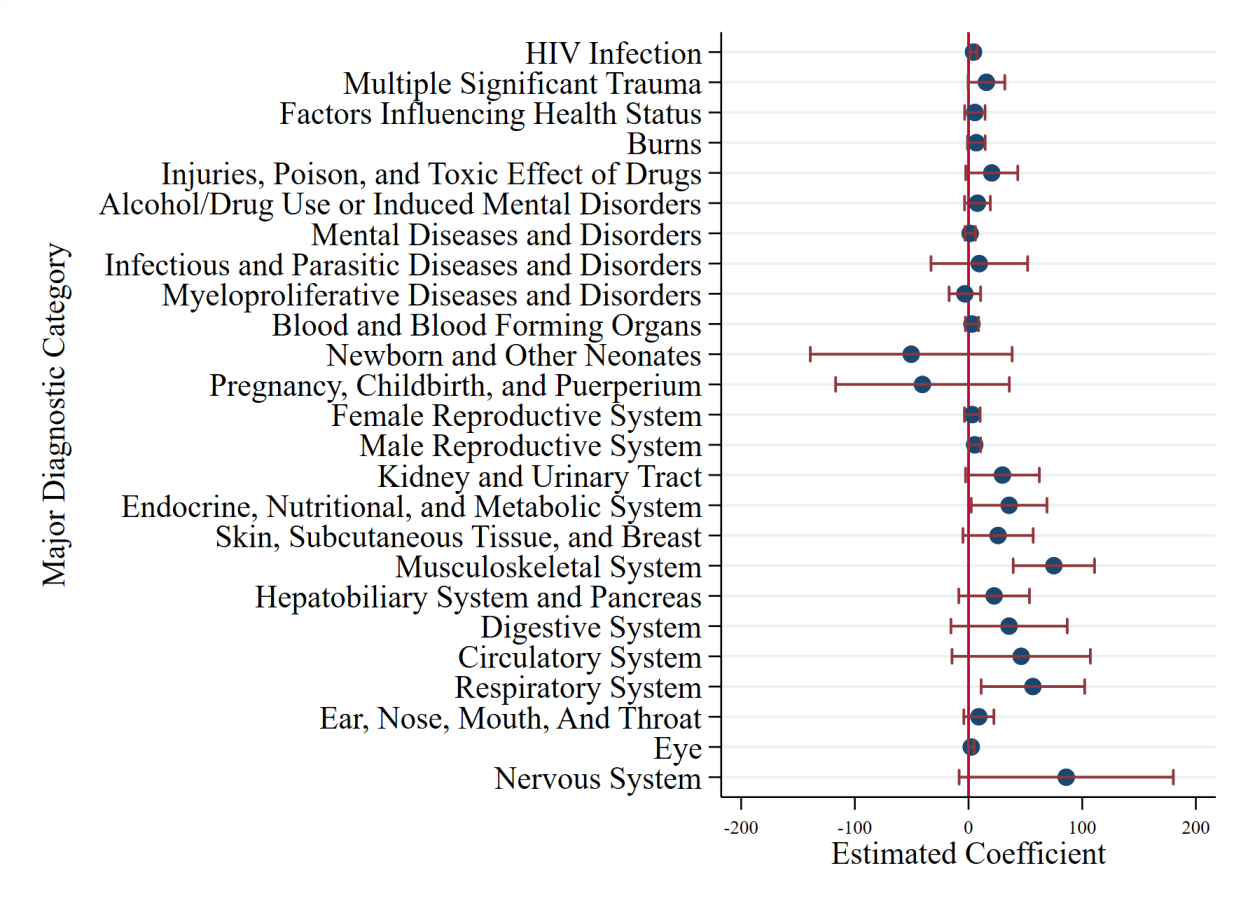


Table S1 Effect of Fatal School Shootings on Inpatient Visits and In-hospital Deaths

	(1)	(2)
Panel A: Inpatient Visits		
Fatal School Shootings	465.56*	414.54**
	(247.82)	(205.28)
N	51576	51576
R2	0.94	0.94
Mean Y	1850.47	1850.47
Covariates	No	Yes
Panel B: In-hospital Deaths		
Fatal School Shootings	15.22	14.88
	(9.42)	(9.17)
N	51576	51576
R2	0.86	0.86
Mean Y	43.34	43.34
Covariates	No	Yes

Note: Each cell reports the result from a two-stage DID regression weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for all patients. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and time fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level. . *** p<0.01, ** p<0.05, * p<0.1.

Table S2 Effect of Fatal School Shootings on Inpatient Visits and In-hospital Deaths, Randomization Inference

	(1)	(2)	(3)
		P-value of Fatal Shooting Estimated Coefficient	
Outcome Variable	Actual	Fully Randomized	Randomized within County
Inpatient Visits, All	0.049	0.000	0.024
Inpatient Visits, Male	0.068	0.000	0.026
Inpatient Visits, Female	0.021	0.006	0.030
Inpatient Visits, White	0.028	0.000	0.018
Inpatient Visits, Non-white	0.093	0.002	0.062
Inpatient Visits, 0-4	0.491	0.036	0.380
Inpatient Visits, 5-17	0.496	0.228	0.388
Inpatient Visits, 18-24	0.725	0.624	0.840
Inpatient Visits, 25-44	0.045	0.000	0.030
Inpatient Visits, 45-66	0.098	0.000	0.048
Inpatient Visits, 65+	0.142	0.002	0.066
In-hospital Death, All	0.111	0.000	0.052
In-hospital Death, Male	0.097	0.000	0.046
In-hospital Death, Female	0.136	0.000	0.068
In-hospital Death, White	0.125	0.002	0.054
In-hospital Death, Non-white	0.105	0.000	0.058
In-hospital Death, 0-4	0.049	0.000	0.064
In-hospital Death, 5-17	0.038	0.004	0.074
In-hospital Death, 18-24	0.075	0.000	0.048
In-hospital Death, 25-44	0.043	0.000	0.022
In-hospital Death, 45-66	0.101	0.000	0.044
In-hospital Death, 65+	0.234	0.006	0.148

Note: P-values reported in Column 1 are based on results from a two-stage DID regression model, weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. P-values reported in Columns 2-3 are based on randomization procedures discussed in Hollingsworth et al. (2022) and are the proportion of times that the absolute value of the actual estimated effect of fatal shootings is smaller than the absolute value of the estimated effect from 500 two-stage DID regressions in which treatment is randomized at the year-month-facility. No restrictions were considered in the estimates reported in Column 2, while for those reported in Column 3, we randomly assigned treatment to another hospital within the county where the school shooting occurred. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table S3 Effect of Fatal School Shootings on Inpatient Visits, Readmissions, and In-hospital Deaths, Sensitivity Analysis

	(1) Inpatient Visits	(3) In-Hospital Deaths
(1) Main Estimate	414.54**	14.88
	(205.28)	(9.17)
(2) Unbalanced Panel	370.43*	12.94
	(198.18)	(8.99)
(3) Outcome per 10^6 County Pop.	396.27*	14.56*
	(202.43)	(8.29)
(4) Log Outcome	0.21**	0.25
	(0.07)	(0.16)
(5) Poisson	0.11**	0.20
	(0.05)	(0.13)
(6) Control hospitals in a 5-10 miles radius	402.38**	16.13*
	(166.85)	(9.49)

Note: Each cell reports the result from two-stage DID (rows 1-4 and 6), and Poisson (row 5) regression models. Regressions are weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Effect of Fatal School Shootings on Inpatient Visits, Readmissions, and In-hospital Deaths by Coverage Type

	(1) Self-pay	(2) Medicaid	(3) Medicare	(4) Private	(5) Other
Panel A: Inpatient Visits					
Fatal School Shootings	34.63	122.54**	107.48	65.32**	84.85*
	(21.11)	(58.98)	(69.42)	(25.75)	(44.28)
N	51576	51576	51576	51576	51576
R2	0.63	0.92	0.94	0.94	0.77
Mean Y	50.58	875.92	509.96	291.83	122.03
Panel B: In-hospital Deaths					
Fatal School Shootings	1.62*	7.31*	3.14	1.13	1.68*
	(0.92)	(3.84)	(2.77)	(0.86)	(0.92)
N	51576	51576	51576	51576	51576
R2	0.36	0.78	0.82	0.66	0.36
Mean Y	1.10	10.54	25.70	4.09	1.91

Note: Each cell reports the result from a two-stage DID regression weighted by total hospital beds. We consider a three-mile radius between hospitals and attacked schools as the criteria to define treatment. All outcomes are at the facility-month level for patients living in zip codes within a three-mile radius of the hospital zip code. The number of hospital beds, the number of operating rooms, the county-level population (all in logs), a binary variable set to one if the hospital is a teaching hospital and zero otherwise, and a binary variable for the occurrence of mass shootings within a three-mile radius of the hospital are also included as explanatory variables. We also control for facility and year-month fixed effects. The capped spikes are 95% confidence intervals clustered at the facility level. *** p<0.01, ** p<0.05, * p<0.

References:

Hollingsworth, A., Wing, C., & Bradford, A. C. (2022). Comparative effects of recreational and medical marijuana laws on drug use among adults and adolescents. *The Journal of Law and Economics*, *65*(3), 515-554.