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NEW PERSPECTIVES ON THE ECONOMICS OF MENTAL HEALTH[‡]

The Lasting Impacts of School Shootings on Youth Psychotropic Drug Use[†]

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In 2020, gun violence surpassed motor vehicle accidents as the leading cause of death among children in the United States (Gebeloff et al. 2022). Contributing to this trend is a rise in gun violence at schools. Over the last decade, the number of school shootings in the United States more than tripled, with 116 shootings affecting over 125,000 students between 2021 and 2023 alone (Cox et al. 2024).

The tragic costs of school shootings in terms of the lives lost are irrefutable and widely discussed. But understanding the full costs of these events requires measuring the impacts on the many others who survive. This paper studies the impacts of school shootings on the mental health of surviving youth over the following 5.5 years, extending prior work by Rossin-Slater et al. (2020). Using prescription-level data covering the majority of psychotropic prescriptions written in the United States and event study designs, we show that the use of psychotropic medication among youth increases by over 25 percent following a fatal school shooting and remains elevated more than 5 years after the event. The vast majority of these increases in psychotropic drug use can be attributed to increased prescribing of antidepressants and antipsychotic medications and, in particular, those that are relevant for the treatment of acute trauma. Additionally, we show that there are sharp and immediate increases in psychotropic prescriptions following a shooting among youth who had not been prescribed a psychotropic medication in the past year. Taken together, these findings suggest that fatal school shootings are followed by substantial and persistent increases in the incidence of youth mental health issues that necessitate psychotropic drug treatment.

Our findings contribute to a large interdisciplinary literature on the consequences of youth exposure to gun violence. Recent work has shown that exposure to gun violence can have adverse effects on youth mental health and the educational and economic trajectories of exposed students (see, e.g., Rossin-Slater et al. 2020; Ang 2021; Bharadwaj et al. 2021; Cabral et al. 2021). Other work has found that detrimental effects of exposure to trauma during childhood can fade quickly with time, a finding attributed to youth resiliency (Agaibi and Wilson 2005). Our work builds on this existing evidence by providing a longer-term analysis of the effects of fatal school shootings on youth mental health, using a comprehensive dataset of psychotropic prescriptions that allows for a detailed examination by drug type and by patient prescription history.

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I. Data

The data used in this paper come from two primary sources. Information about school shootings comes from the *Washington Post* school shootings database, which tracks shootings at primary and secondary schools in the United States since the massacre at Columbine High School in April 1999 (Cox et al. 2024). As in Rossin-Slater et al. (2020), we consider the impacts of the 15 fatal school shootings that took place between February 2008 and January 2013.[1]

Data on prescriptions come from the IQVIA Longitudinal Prescription Data (LRx) database, which contains information on the near universe of prescriptions filled in the United States. We use a new extract of the LRx data that allows us to extend the findings in Rossin-Slater et al. (2020) in four key ways. First, the data cover the years 2006–2018. This sample period allows us to consider outcomes measured in a balanced panel of two years before to five and a half years after each event in our sample, more than doubling the two-year postperiod window considered in Rossin-Slater et al. (2020). Second, the new data extract contains information on the prescribing of antidepressants, antipsychotics, and antianxiety medications. This allows us to study a broader set of psychotropic drugs than Rossin-Slater et al.'s (2020) analysis of antidepressants.[2] Third, the LRx data contain prescription-specific information on drug products. This allows us to aggregate drugs across classes on the basis of their relation to the treatment of acute trauma in some analyses, which we do using an established pharmacology manual (Schatzberg and DeBattista 2019). Finally, the LRx data contain an (anonymized) patient identifier. This allows us to examine whether any increases in prescribing are driven by prescriptions for patients who were or were not already taking psychotropic medications.

Following Rossin-Slater et al. (2020), we define the treatment area for each shooting as the 5-mile radius around the geographic coordinates of the school where the shooting occurred ("near" area), and we define the control area as the area 10–15 miles away ("far" area). Our analysis considers prescriptions written by providers practicing within either the treatment or the control area of each school.[3] We further restrict our sample to prescriptions written to patients who were between the ages of 5 and 19 years old at the time of the shooting. The granularity in patient age available in the LRx data allows us to precisely measure the long-term effects of shootings by following the exposed cohort as they age. That is, we consider prescriptions written for 6- to 20-year-olds one year after the shooting, 7- to 21-year-olds two years after the shooting, and so on.[4]

We use prescription rates in some analyses. To construct the denominator for these rates, we use population data at the age–by–census block group (CBG) level from the 2006–2010 five-year pooled American Community Survey (ACS) and measure the number of individuals in the relevant age group (5–19, 6–20, 7–21, and so forth) in all CBGs whose centroids are contained within either 0–5 or 10–15 miles from a school in our analysis sample (US Census Bureau 2006–2010).[5]

II. Empirical Design

After making these sample restrictions, we aggregate our data monthly to the school-by-area (near or far) level and estimate event study specifications of the following form:

$$(1) \qquad RX_{ast} = \sum_{\substack{q=-8 \\ q\neq -1}}^{22} \beta_q \cdot Near_a \times \mathbf{1}_{q(s,t)} + \sigma_t + \delta_{as} + \varepsilon_{ast},$$

[1] We define fatal shootings as those involving at least one victim death. Rossin-Slater et al. (2020) further examine the effects of 29 nonfatal shootings and find no significant impacts on antidepressant prescribing for youth in the following two years.

[2] We refer to the aggregation of these three drug classes as "psychotropic medications" for simplicity. We note that we do not have information on the prescribing of stimulants or mood stabilizers, the two other drug classes that are typically considered psychotropic medications (Schatzberg and DeBattista 2019).

[3] Provider practice addresses come from the American Medical Association and reflect provider locations as of 2014.

[4] Rossin-Slater et al. (2020) were limited to studying patients who were 19 and younger in a given year of observation.

[5] We assume that ages are distributed uniformly within age bins provided by the ACS.

Table 1—Descriptive Statistics

	Youth prescriptions per 1,000			
	Treatment areas (0–5 miles)		Control areas (10–15 miles)	
	Preshooting (1)	Postshooting (2)	Preshooting (3)	Postshooting (4)
Aggregate psychotropic	9.91	17.63	9.69	13.58
By drug class				
Antidepressant	4.88	10.36	4.93	8.11
Antipsychotic	3.33	4.78	3.32	3.26
Antianxiety	1.70	2.49	1.44	2.20
By trauma relation				
Trauma-related	6.70	13.00	6.66	9.73
Non-trauma-related	3.21	4.63	3.02	3.85

Notes: The table shows average monthly psychotropic prescription rates per 1,000 youth for providers practicing 0–5 miles from schools that experienced a fatal school shooting (treatment areas; columns 1 and 2) and for providers practicing 10–15 miles away (control areas; columns 3 and 4). These statistics are provided both for the two years before the shooting (columns 1 and 3) and for the five and a half years after the event (columns 2 and 4). The month in which the shooting took place is excluded from these figures. Our sample includes the 15 fatal school shootings considered in Rossin-Slater et al. (2020).

where RX_{ast} denotes a prescription outcome in area a of school s in month t, and $Near_a$ is an indicator denoting the near area (i.e., the treatment group). Defining q in event time for each shooting, the indicators $\mathbf{1}_{q(s,t)}$ denote the 8 quarters before to the 22 quarters after each event; the quarter before the event is the omitted category. We include month-by-year fixed effects, σ_t, and school-by-area fixed effects, δ_{as}, to control for general time trends and time-invariant differences across locations, respectively. ε_{ast} is an idiosyncratic error term. We weight observations by school enrollment and cluster standard errors at the school-by-area level.[6]

The coefficients of interest, β_q, measure the difference in youth psychotropic prescriptions between treatment and control areas in each quarter relative to the quarter before the shooting. To interpret these coefficients as the causal effects of school shootings, it must be the case that youth psychotropic prescriptions would have evolved similarly across the treatment and control areas in the absence of a shooting.

III. Results

Table 1 provides descriptive statistics for monthly psychotropic prescription rates per 1,000 youth in treatment and control areas in the two years before and the five and a half years after fatal school shootings. We present prescription rates for our aggregate measure of psychotropic drug use in addition to prescription rates by drug class (antidepressant, antipsychotic, antianxiety) and by appropriateness for the treatment of acute trauma.

For the age groups in our analysis sample, antidepressant prescriptions are the most common, followed by antipsychotics and then antianxiety medications. Due to the abuse potential of antianxiety medications such as benzodiazepines, which are controlled substances, prescriptions for such medications are relatively rare for youth and become more common postadolescence (Kodish, Rockhill, and Varley 2011; see online Appendix Figure S1).[7] Both for aggregate psychotropic drugs and across drug classes and trauma relation indication, preshooting prescription rates for youth are very similar between the treatment and control

[6] Online Appendix Figure S2 provides alternative confidence intervals based on a wild cluster bootstrap.

[7] Anxiety disorders in children and adolescents are more commonly treated with selective serotonin reuptake inhibitors, a class of antidepressants (Kodish, Rockhill, and Varley 2011).

areas, giving credence to the assumption that the far areas represent an appropriate control group. In the five and a half years after a fatal school shooting, we see a marked increase in aggregate prescriptions in the treatment group relative to the control group. This increase is driven primarily by antidepressant and antipsychotic drugs and, in particular, by drugs relevant in the treatment of acute trauma.

Panel A of Figure 1 plots average monthly psychotropic prescription rates per 1,000 youth from the two years before to the five and a half years after a fatal school shooting. These raw trends are shown separately for the treatment (solid red squares) and control (hollow blue circles) areas. Prior to a shooting, youth psychotropic prescription rates were on similar trends and were at similar levels in the treatment and control areas. Following a shooting, youth psychotropic prescription rates in the treatment group sharply deviate from the baseline trend and stay elevated above control group levels through the end of the sample period. While psychotropic prescription rates increase steadily in the control group over time—a pattern that reflects both the increased use of psychotropic medications with age as well as general time trends—there is no noticeable change in prescription rates in the control group that coincides with the timing of the shooting.

We formalize this comparison in prescription outcomes between the treatment and control areas using an event study design. Results from estimation of equation (1) using the natural log of total psychotropic prescriptions for youth as the outcome are shown in panel B of Figure 1.[8] As was shown in the raw data plot, we see that treatment and control areas followed similar trends before the shooting. Immediately following a fatal school shooting, however, the treatment group experiences a clear and persistent increase in psychotropic prescriptions. At its peak, fatal school shootings cause psychotropic prescriptions for youth to increase by over 25 percent. Although these effects fade slightly after three and a half years, youth psychotropic prescription use remains elevated even five years after the event.

[8] Online Appendix Figure S3 shows that the results are very similar when we use estimators recently proposed in the econometrics literature in place of a standard two-way fixed effects regression.

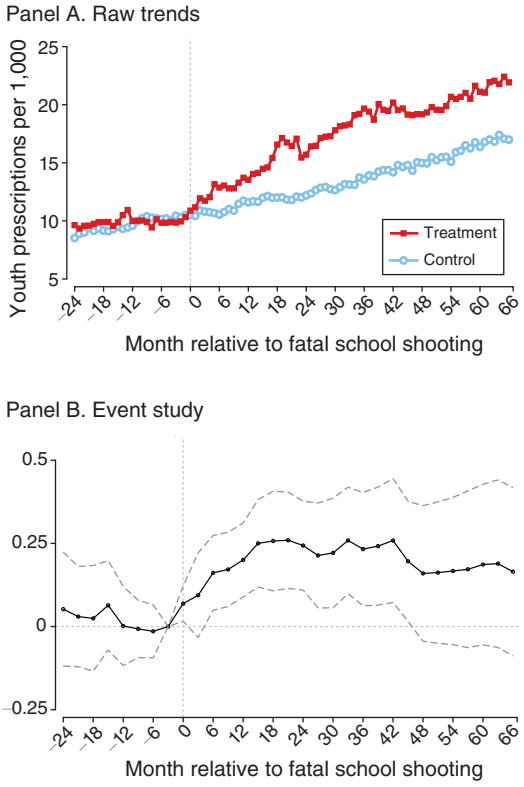

FIGURE 1. EFFECT OF FATAL SCHOOL SHOOTINGS ON PSYCHOTROPIC PRESCRIPTIONS FOR YOUTH

Notes: Panel A plots monthly averages of psychotropic prescribing rates per 1,000 youth in treatment areas (0–5 miles; solid red squares) and control areas (10–15 miles; hollow blue circles) in the months surrounding a fatal school shooting. Panel B presents coefficients and 95 percent confidence intervals from estimation of equation (1) using the natural logarithm of youth psychotropic prescriptions as the outcome. Observations in both panels are weighted by school enrollment. Our sample includes the 15 fatal school shootings considered in Rossin-Slater et al. (2020).

We further estimate equation (1) using aggregate psychotropic prescriptions per 1,000 youth as the outcome to quantify the number of additional psychotropic prescriptions caused by fatal school shootings. Results from this analysis reveal that the effects of fatal school shootings on youth psychotropic drug use peak approximately three years after the event at nearly six additional psychotropic prescriptions per 1,000 youth. This effect on aggregate prescribing is shown in the leftmost bar of Figure 2.

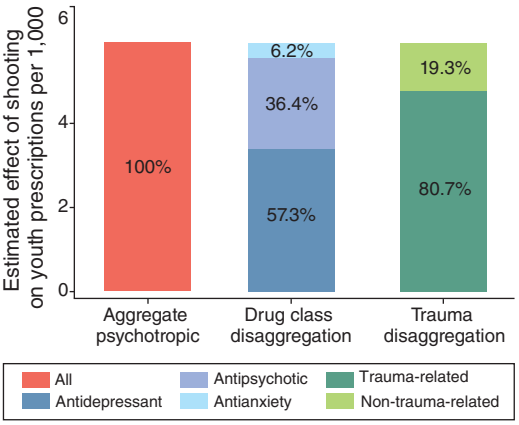

FIGURE 2. DECOMPOSITION OF EFFECTS BY DRUG CLASS AND TRAUMA RELATION

Notes: The figure decomposes the estimated effect of exposure to a fatal school shooting on aggregate psychotropic prescriptions per 1,000 youth (leftmost bar) by drug class (middle bar) and trauma relation (rightmost bar). To do so, we estimate equation (1) using prescription rates per 1,000 youth separately for aggregate psychotropic drugs, by drug class, and by use for the treatment of acute trauma. We then divide the subgroup impacts by the aggregate effect on psychotropic prescribing to determine the percent of the aggregate increase that can be accounted for by each drug type. This decomposition is done for the peak one-year effect on aggregate psychotropic prescription rates, which occurs 2.75–3.75 years after a school shooting.

We can decompose these aggregate effects of fatal school shootings on youth psychotropic drug use by drug class. To do so, we estimate equation (1) using prescription rates per 1,000 youth for each drug class as the outcome.[9] Following a fatal school shooting, we find that antidepressant, antipsychotic, and antianxiety prescribing for youth increases by around 3.4, 2.2, and 0.4 prescriptions per 1,000 people, respectively. As shown in the middle bar in Figure 2, these findings indicate that 57 percent of the aggregate increase in psychotropic prescribing is driven by increased use of antidepressants, 36 percent is driven by increased use of antipsychotics, and 6 percent is driven by increased use of antianxiety medications.

[9] Raw trends in prescription rates by drug class in the treatment and control areas are shown in online Appendix Figure S4. Since the sample ages in event time, the trends in the control areas mirror the age paths of prescription use by drug class shown in online Appendix Figure S1.

We are further interested in whether the increases in prescribing are driven by medications that are relevant for the treatment of acute trauma. Estimating equation (1) using psychotropic drugs that are commonly used to treat acute trauma per 1,000 youth shows that fatal school shootings lead to an increase in nearly five such prescriptions, an effect that accounts for over 80 percent of the aggregate increase in psychotropic prescribing (rightmost bar in Figure 2).[10] The prescribing of pscyhotropic drugs not commonly used in the treatment of trauma increases by about one prescription per 1,000 youth, or less than 20 percent of the aggregate prescribing increase.

Beyond variation by drug type, we can also investigate effect heterogeneity by patient type. Figure 3 shows raw quarterly trends in the treatment areas (solid red squares) and control areas (hollow blue circles) for patients who were not prescribed a psychotropic medication in the prior year ("naïve" patients; panel A) and those who were ("nonnaïve" patients; panel B).[11] Panel A shows a sharp, immediate increase in psychotropic prescriptions among naïve patients. This finding indicates that some of the immediate effects of fatal school shootings occur on the extensive rather than on the intensive margin. Patients who had previously been taking psychotropic medication also see a substantial increase in prescriptions, with fewer immediate effects. In absolute terms, however, the effect size for nonnaïve patients is much larger than for naïve patients, especially in the longer term.[12]

IV. Discussion

School gun violence is increasingly prevalent in the United States, underscoring the

[10] See online Appendix Figure S5 for raw trends in youth prescription rates by trauma categorization in the treatment and control areas.

[11] The patterns are very similar if we require that patients must not have received a psychotropic prescription from any provider in the prior six months, rather than in the prior year, to be classified as "naïve."

[12] By construction, naïve patients who are prescribed psychotropic medication are categorized as nonnaïve for the next year. Some of the gradual increase in prescriptions for nonnaïve patients over time could therefore be driven by naïve patients who receive their first prescription following a school shooting staying on the medication for an extended period of time.

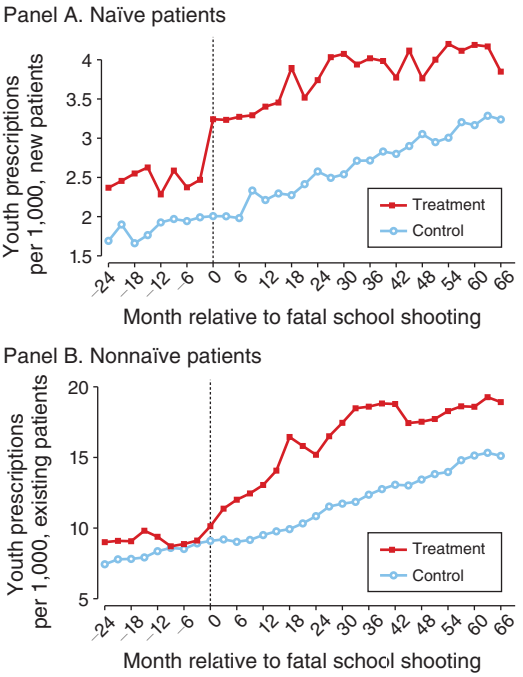

Figure 3. Effect Heterogeneity by Patient Margin

Notes: The figure plots quarterly averages of psychotropic prescription rates per 1,000 youth in treatment areas (0–5 miles; solid red squares) and control areas (10–15 miles; hollow blue circles) in the months surrounding a fatal school shooting. These rates are shown separately for patients who had not been prescribed a psychotropic medication in the previous year ("naïve" patients; panel A) and for those who had ("nonnaïve" patients; panel B). Observations are weighted by school enrollment. For this figure only, we consider the subset of 11 fatal school shootings considered in Rossin-Slater et al. (2020) that occurred between February 2009 and January 2013; this shorter time window for event inclusion is required to allow for an additional year of preperiod data to observe patients' prior-year prescription history over the entire balanced panel window.

need for a comprehensive understanding of its consequences for exposed youth. While prior literature has documented that exposure to violence can immediately impact mental health, there is less evidence on the extent to which these impacts persist. Some studies measuring the impacts of childhood exposure to traumatic events have shown that children can "bounce back" and recover quickly, limiting the potential for exposure to trauma during childhood to cause long-term harm (Agaibi and Wilson 2005). Consistent with this notion, earlier work has found that child performance on cognitive tests fades with time from exposure to violence in the local neighborhood (Sharkey 2010). However, in the context of school shootings, other work has found long-term consequences of exposure on college completion and earnings in adulthood (Cabral et al. 2021).

The results from this paper suggest that the mental health impacts of fatal school shootings on youth are remarkably persistent, with psychotropic prescribing rates remaining elevated up to five and a half years following exposure. These impacts are driven by prescriptions for antidepressants and antipsychotics and by drugs relevant for treating acute trauma. Moreover, these effects materialize among both new and existing patients, suggesting a pervasive and lasting deterioration in youth mental health.

Our findings are relevant in the context of a broader trend of worsening youth mental health in the United States. In 2021, more than 40 percent of high school students reported persistent feelings of sadness or hopelessness, a nearly 50 percent increase from 2011 (Centers for Disease Control and Prevention 2022). This paper suggests that the increasing prevalence of school gun violence may have contributed to this trend. Our findings also underscore the urgent need to identify effective policies that can provide support to the hundreds of thousands of youth who have already experienced gun violence at their schools in addition to adopting policies to prevent shootings from happening in the first place.

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