# THE EFFECT OF COMMUNITY TRAUMATIC EVENTS ON STUDENT ACHIEVEMENT: EVIDENCE FROM THE BELTWAY SNIPER ATTACKS



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**Abstract**
Community traumatic events such as mass shootings, terrorist attacks, and natural disasters have the potential to disrupt student learning. For example, these events can reduce instructional time by causing teacher and student absences, school closures, and disturbances to classroom and home routines. This paper uses a quasi-experimental research design to identify the effects of the 2002 "Beltway Sniper" attacks on student achievement in Virginia's public elementary schools. To identify the causal impact of these events, the empirical analysis uses a difference-in-differences strategy that exploits geographic variation in schools' proximity to the attacks. The main results indicate that the attacks significantly reduced school-level proficiency rates in schools within five miles of an attack. Evidence of a causal effect is most robust for math proficiency rates in the third and fifth grades, and third-grade reading proficiency, suggesting that the shootings caused a decline in school proficiency rates of about 2 to 5 percent. Particularly concerning from an equity standpoint, these effects appear to be entirely driven by achievement declines in schools that serve higher proportions of racial minority and socioeconomically disadvantaged students. Finally, results from supplementary analyses suggest these deleterious effects faded out in subsequent years.

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## 1. INTRODUCTION

In contrast to the significant drop in crime in the United States over the last two decades, the frequency of community traumatic events, such as terrorist attacks, mass shootings, and natural or man-made disasters, has increased during this time period. For example, a study conducted by the U.S. Federal Bureau of Investigation identified 160 incidents involving active shooters, in which 486 individuals were killed and 557 individuals were wounded between 2000 and 2013 (U.S. Department of Justice 2013).[1] The frequency of such events has increased significantly during this time period, as an average of 6.4 active shooter incidents occurred annually between 2000 and 2006 compared with an average of 16.4 such incidents per year between 2007 and 2013. Another study focusing on the time interval between incidents reached a similar conclusion (Cohen, Azrael, and Miller 2014). This pattern has heightened awareness of the need for effective policies designed to protect children and communities from the direct and indirect effects of such violent acts.[2]

Accumulating evidence indicates that exposure to violent traumatic events, such as domestic violence, terrorism, random school shootings, and community traumatic events in general, harms the health and well-being of children, as measured by depression, aggressive behavior, anxiety and stress, social and emotional problems, and impaired cognitive development and academic achievement (Fremont 2004; Hoven et al. 2005; Danese et al. 2009; Wendling 2009; Currie and Tekin 2012; Daniels and Haist 2012; Di Pietro 2015).

The potential effects of community traumatic events on student learning can operate through both direct and indirect channels. Direct channels can include school absenteeism and poor academic performance at school due to a lack of focus associated with anxiety and fear, and indirect channels can include disruptions created by parents and teachers who experience problems themselves. Moreover, children do not have to be direct victims or witnesses of community traumatic events to be harmed: indirect exposure such as learning about a violent death or serious injury, the fear of death to self or a family member, an increased sense of vulnerability or helplessness, or repeatedly engaging with trauma-related stories via the media can also harm children's well-being (Pfefferbaum et al. 2001; Saylor et al. 2003; Calderoni et al. 2006; Becker-Blease, Finkelhor, and Turner 2008; Holman, Garfin, and Silver 2014).

This paper provides insights into the impact of community traumatic events on student achievement using the 2002 "Beltway Sniper" attacks as a natural experiment.[3] As explained in section 2, the Beltway Sniper attacks were a series of coordinated shootings of individuals targeted randomly but living in the Washington, DC, metropolitan area

1. According to the FBI, "Active shooter is a term used by law enforcement to describe a situation in which a shooting is in progress and an aspect of the crime may affect the protocols used in responding to and reacting at the scene of the incident. Unlike a defined crime, such as a murder or mass killing, the active aspect inherently implies that both law enforcement personnel and citizens have the potential to affect the outcome of the event based upon their responses" (U.S. Department of Justice 2013).
2. One such example is the Investigative Assistance for Violent Crimes Act of 2012, which authorizes the Department of Justice to investigate mass shootings in public places.
3. Our definition of community traumatic events refers to incidents that affect entire communities by causing physical, emotional, or psychological distress, or harm to persons living in them. Individuals exposed to these events must experience changes in their daily lives to an extent that often overwhelms them and leads to conditions beyond their control, often resulting in depression, post-traumatic stress disorder, and suicidality (Praetorius 2006).

and along Interstate 95 (I-95) in Virginia. The attacks left ten people dead and three people critically injured over a period of three weeks in October 2002. The question considered in this paper is an important one because the relationship between community traumatic events and student achievement has implications for both proactive and reactive policy making. Regarding the former, debates over the costs and benefits of policies to prevent community traumatic events or minimize their harmful consequences for the public could be significantly influenced by evidence that these events have a negative impact on student achievement. For instance, if children who are indirectly exposed to these events suffer significant setbacks at school, this would motivate efforts to identify policy interventions designed to prevent these events from occurring and to reduce exposure among children. Regarding the latter, the strength of the relationship between community traumatic events and academic achievement, and the types of students who are most affected by the trauma associated with these events, has important implications for the optimal provision of school and community resources following a traumatic incident.

Our analysis improves upon existing research along several dimensions. First, we carefully address the endogeneity of exposure to community traumatic events by exploiting schools' geographic distances from the locations of each of the sniper attacks as a measure of "intensity of treatment." In other words, variation in the intensity of exposure, as measured by the distance between schools and shooting sites, allows us to identify the causal impact of these attacks on student achievement using a difference-in-differences (DD) estimation strategy. More specifically, we compare the proficiency levels of students attending schools that are located near one of the shooting sites before and after the shooting incident to the proficiency levels of students attending schools farther away from the shooting sites. Proficiency rates are an important, policy-relevant measure of schools' academic performance, as they are the measure by which schools were graded by the federal No Child Left Behind Act (NCLB).

Second, unlike most of the extant literature that focuses on outcomes of psychological well-being, we consider academic achievement of children as the outcome measure. Psychological manifestations of traumatic events on children may sometimes be latent or the symptoms may not be promptly recognized by parents. It is also possible that children and parents are reluctant to acknowledge and seek help for these problems because of social stigma. Unlike psychological symptomology, academic outcomes are arguably more objective and easily observable—by parents, teachers, and school administrators—measures of the consequences of psychological trauma associated with exposure to community traumatic events. Because affected students may have negative spillovers on their classmates, a finding of any impact on academic outcomes would also provide compelling justification for the public and policy makers to be concerned about how to best help affected children (Carrell and Hoekstra 2010).

Third, our outcome measures are school-level proficiency rates obtained from official school records. Therefore, they are not subject to the reporting error potentially inherent in subjective parental reports of their children's academic proficiency. This is potentially an important improvement because parental reports can be problematic if, for example, trauma associated with these events impairs parents' ability to report or remember accurately. Alternatively, some parents may have a tendency to relate any academic problems their children are experiencing to these tragic events.

Finally, unlike most other human-action and natural disasters, terrorist attacks, and school shootings, the beltway sniper attacks were prolonged and intermittent in nature. In this sense, the psychological manifestations caused by these attacks may more closely resemble those caused by the chronic community violence that is endemic to many inner-city neighborhoods in the United States.[4] Millions of children—15 percent to 43 percent of girls and 14 percent to 43 percent of boys—experience at least one traumatic event while growing up (U.S. Department of Veteran Affairs 2014). Regardless of the cause of the traumatic stressors, these children are likely to exhibit a wide range of reactions that can affect many facets of their lives, including educational achievement and attainment. Therefore, the results of the current study are likely to provide a reliable and representative assessment of the impact of childhood exposure to the type of stress experienced by a large segment of the United States population.

Our results provide robust evidence in support of a causal relationship between exposure to the sniper attacks and math and reading proficiency of students in third and fifth grades. Specifically, the results suggest that the shootings caused a decline in school proficiency rates of about 2 percent to 5 percent. These effects are similar in magnitude to those obtained in Marcotte and Hemelt (2008) of the impact of ten unscheduled snow-related school closures on math and reading assessments of students in similar grades in Maryland. Our estimates are also large enough to have changed the standing of a nontrivial number of schools' Adequate Yearly Progress (AYP) designations in the first year of the NCLB. These results are fairly robust to the operationalized definition of "closeness" to a sniper attack, controlling for time-variant school characteristics and school district linear time trends, and accounting for overlap in the schools affected by the attack on the Pentagon on 11 September 2001, which occurred in the year preceding the sniper attacks. Particularly concerning from an equity standpoint, harm caused by the sniper attacks appears to be primarily driven by achievement declines in schools that predominantly serve racial minority and socioeconomically disadvantaged students. Finally, we show that the reductions in school proficiency caused by the sniper attacks were relatively short-lived, fading out in subsequent academic years.

## 2. BACKGROUND

A voluminous literature in psychology describes the relationship between childhood exposure to traumatic events and psychological well-being. Many studies in this literature suggest an association between exposure to traumatic events and psychological health. However, these studies are mostly based on conceptual considerations and descriptive empirical analyses that fail to adequately address the problem of endogenous exposure to traumatic events. These investigations typically rely on information drawn from samples of interviews of individuals who were exposed to traumatic events such as the September 11, 2001 terrorist attack (Beauschesne et al. 2002; Halpern-Felsher and Millstein 2002; Hoven et al. 2005; Neria, DiGrande, and Adams 2011), the 1995 Oklahoma City bombing (Pfefferbaum et al. 1999, 2000), or Hurricane Katrina (Spell et al.

4. A recent article by Monteiro and Rocha (2017) considers drug battles between gangs that take place in favelas [slums] in Rio de Janeiro. Using variation in violence that occurs across time and space when gangs battle over territories, the authors find that exposure to such violence reduces student achievement in math. To the extent that drug-related gang violence constitutes an extreme episode of a community-wide traumatic event, this study is informative for the purposes of our analysis.

2008). Several empirical studies acknowledge the potential endogeneity of exposure to community traumatic events, but attempt to address this problem by conditioning on a minimal set of control variables in a multivariate regression framework. This is an important limitation of the literature because children are unlikely to be exposed to these events exogenously. In other words, children who are exposed to community traumatic events may have certain attributes that contribute to their poor outcomes regardless of the traumatic events to which they are exposed. For example, if these events are more likely to take place in neighborhoods with high poverty and crime rates or in communities lacking the necessary resources to cope with the aftermath of traumatic events, conclusions drawn from correlational studies may overestimate the true impact of exposure to community traumatic events.

Similarly, parenting style and specific behaviors adopted by parents in response to community traumatic events can influence the extent of the harm caused to their children.[5] For example, some parents may attempt to minimize the harm of these events to their children by limiting children's exposure to news media or by spending more time with them. Alternatively, rigid work schedules or their own stresses may limit the amount of extra care and emotional support they are able to provide to their children during these times. Even worse, the stress experienced by parents might lead to counterproductive behaviors, which may further fuel anxiety and fear among children—for example, by following trauma-related news stories in front of their children. Failing to account for these behavioral responses or changes in parenting styles would cause an upward bias in the case of "negative" parenting style and a downward bias in the case of "positive" parenting style.

Another limitation is that the extant literature largely relies on self-reported retrospective data drawn from interviews of parents about the exposure of their children to these events or interviews of affected older children. Because information on both exposure and reactions come from the same source, these data may suffer from systematic measurement error. For example, parents whose children are performing poorly at school may attribute this problem to past exposure to a traumatic event. Relatedly, as a practical matter, the analysis samples are self-selected in the sense that researchers only have data on individuals who agreed to be interviewed. In summary, credible estimation of the impact of community traumatic events on children's well-being poses numerous challenges that the extant literature has failed to systematically address. We contribute to this literature by applying a DD method to statewide, objective data on primary school proficiency rates that are immune to these concerns.

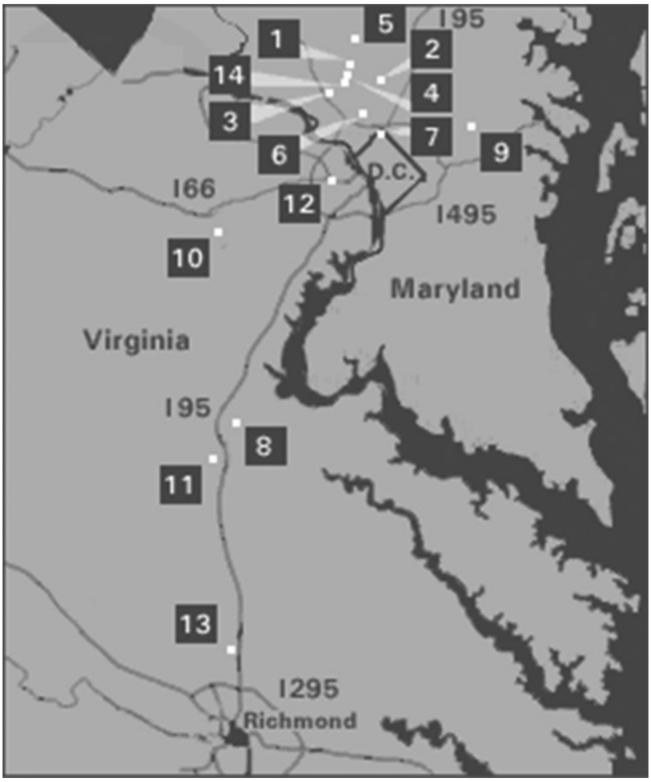
Recently, studies examining the short-run effects of acute, extreme violence have addressed many limitations of earlier research. Specifically, a series of papers by Patrick Sharkey and coauthors (Sharkey 2010; Sharkey et al. 2012, 2014) exploit the arguably random temporal variation in extreme violence (i.e., homicides) in inner city neighborhoods in Chicago and New York to estimate the effect of proximity to such incidents on standardized tests and other developmental assessments. The authors identify arguably causal effects by noting that conditional on living in a neighborhood that experiences

5. There are studies emphasizing the importance of parental behaviors in influencing the consequences of traumatic events on children (Buka et al. 2001; Plybon and Kliewer 2001), which have been shown to vary by socioeconomic status (Guryan, Hurst, and Kearney 2008; Kalil, Ryan, and Corey 2012).

extreme violence, whether incidents of extreme violence occur in the week before, or week after, the educational assessment is as good as random. In both New York and Chicago, the authors find robust evidence that acute exposure to violence in the week preceding the assessment reduces performance on English Language Arts (ELA) test scores, attention, and impulse control relative to a control group of children who were acutely exposed to extreme violence in the week following the assessment. Similarly, recent research on the impact of school shootings (i.e., homicides that occurred on school grounds) finds that fatal school shootings reduce high school proficiency rates by about 4 to 5 percentage points in both math and ELA (Beland and Kim 2016). The harmful effects are even larger in more severe incidents that resulted in multiple deaths. These effects are identified using a school-district fixed effects DD strategy, where the control group is composed of schools that did not experience a school shooting but are in the same district as a school that did. Similarly, Poutvaara and Ropponen (2018) exploit a school shooting that occurred in Finland right before high school seniors took their national matriculation exams, which is associated with a 7 percent nationwide decline in male performance on the exam.

These studies represent important advances in our understanding of the causal relationship between acute exposure to extreme violence and cognitive development. Although the present study constitutes a fresh contribution to the growing line of analyses that take serious steps to address the endogeneity problem, it also extends the literature in a number of important dimensions. For example, the other studies (e.g., those by Sharkey and coauthors) are limited to neighborhoods in large, urban centers that have relatively little sociodemographic diversity, which may not be representative for the impact of unpredictable and purely random tragedies that are increasingly taking place in the United States. Furthermore, the identification strategy used by Sharkey and coauthors only allows for the identification of impacts that manifest in the immediate aftermath (e.g., one week) of the events. Finally, all of the studies focus on incidents of acute violence that do not necessarily generalize to broader, community-wide stressors that play out over longer time horizons. Using an identification strategy that can examine the persistence of such effects, the current study contributes to the literature discussed above by considering the Beltway Sniper attacks, which created a high degree of stress and uncertainty and took place over a period of three weeks across a large, sociodemographically diverse section of the country.

A related literature studies the effect of large-scale violent events (e.g., civil wars) using data from countries such as Guatemala (Chamarbagwala and Morán 2011), Israel (Brück, Di Maio, and Miaari 2014), Peru (León 2012), Rwanda (Akresh and Walque 2008), and Tajikistan (Shemyakina 2011). These studies consistently find that individuals exposed to such events experience worse educational outcomes. However, the types of events analyzed in these studies often disrupt many aspects of life, including economic and political systems, and destroy infrastructure. In contrast, the Beltway Sniper attacks investigated in the current study did not destroy physical infrastructure nor did they create sociopolitical upheaval, suggesting that the mechanisms through which the sniper attacks might have influenced educational outcomes were quite different than those in previous analyses of large-scale violent events. In this sense, our paper more closely resembles recent studies of the impact of episodes of violent conflict between




Source: Clark County Prosecutor, www.clarkprosecutor.org/html/death/US/muhammad1181.htm.

**Figure 1.** Locations of the Beltway Sniper Attacks

drug gangs and security forces or among the gangs themselves in Mexico (Márquez-Padilla, Pérez-Arce, and Rodriguez-Castelán 2015; Romano 2015) and Brazil (Monteiro and Rocha 2017). However, none of these studies focuses on the United States. Therefore, the generalizability of findings from these studies to other contexts is not straightforward, especially because the settings analyzed in those papers have substantially higher baseline levels of violence than the United States.

## 3. THE BELTWAY SNIPER ATTACKS

The Beltway Sniper attacks were a series of coordinated shootings carried out in October 2002 in the Washington, DC, metropolitan area and along I-95 in Virginia. The locations of these shootings are marked in the map displayed in figure 1. Between 2 and 24 October, ten people were fatally shot and another three people were critically injured by rifle bullets fired from some distance with marksman accuracy. Five of the shootings took place in Virginia, resulting in three fatalities and two serious injuries. One of the shootings targeted a 13-year-old student, who was wounded by a single bullet that struck him in the chest "as he waited in front of the school for the doors to be opened" (*John Allen Muhammad v. Maryland* 2007, p. 12). The shootings sparked one of the largest criminal manhunts in U.S. history until the two suspects, who were later found guilty of these shootings, were captured on 24 October.[6]

The shootings were sporadic in nature, as victims were shot while mowing grass, reading on a bus station bench, walking in the parking lot of a grocery store, and pumping gas at a gas station. The unexplained and random nature of the shootings inflicted a tremendous deal of stress and fear among people living in and around the communities where the shootings occurred. This stress and fear prompted many local residents to modify behaviors, such as skipping work and school, running or weaving through parking lots, canceling outdoor activities, and avoiding shopping centers and gas stations nearby I-95 (Coppola 2004; Zivotofsky and Koslowsky 2005; Mitchell 2007). The shootings also occupied both local and national media attention during this period, which further contributed to public fear and anxiety (Mitchell 2007). Media coverage was so intense that 503 articles appeared in the *Washington Post* alone during the three-week period of shootings (Muzzatti and Featherstone 2007).[7]

As fear quickly spread throughout neighboring communities, many parents reacted by preventing their children from taking the school bus or walking home alone and instead driving children to school. Schools went on “lockdown” and canceled outdoor events such as soccer games and field trips.[8] Schools in Chesterfield, Goochland, Hanover, Henrico, and Powhatan counties in Virginia and the city of Richmond closed for multiple days as a result of the shootings (Prothero 2002). The number of school children affected by school closings reached about 200,000 in Richmond alone (*Shreveport Times* 2002). Furthermore, many parents voluntarily kept their children home even when schools remained open. As a result, there was a significant increase in absenteeism with daily attendance rates falling as low as 10 percent at elementary schools close to one of the shootings (Schulte 2002).

Porter (2010) provides an in-depth qualitative analysis of the experiences of school personnel and the emergency response by school district administrators to the shootings in Montgomery County, Maryland. Although Porter does not provide any insights into the potential impact of the attacks on student achievement, the analysis is helpful in understanding the psychological ordeal experienced by various actors involved in the lives of children affected by the shootings, including parents, teachers, and school administrators. Aside from this qualitative study, most of our knowledge about the impact of the sniper attacks comes from reviews of newspaper articles and a few studies based on interviews of a small number of parents and children who had lived near shooting sites. These studies suggest that geographic proximity to the attack sites was an important contributor to psychological symptomology exhibited by children such as increased vulnerability and stress (Butler, Panzer, and Goldfrank 2003; Mitchell 2007; Becker-Blease, Finkelhor, and Turner 2008).

Becker-Blease, Finkelhor, and Turner (2008) analyzed data from the Developmental Victimization Survey, which was conducted between December 2002 and

6. One of the perpetrators was sentenced to death and his execution was carried out in 2009. The other was sentenced to six consecutive life sentences without the possibility of parole.
7. Accordingly, over 70 percent of citizens reported that they had followed the news more than usual during the weeks of the sniper attacks, which highlights the role of media in shaping the public perceptions during the period (Coppola 2004; Mitchell 2007).
8. See www.crimemuseum.org/crime-library/the-washington-dc-sniper.

February 2003. Focusing on the sample of respondents from Maryland ($N = 30$), Virginia ($N = 49$), and Washington, DC ($N = 2$), the authors found increased stress and worry among children, with more apparent signs among minority children and those from low-income households. Similarly, these children were also more likely to change their daily routines during the period of shootings. Furthermore, children living in neighborhoods near the shooting locations were likely more severely affected than children elsewhere in Virginia and Maryland, as well as the rest of the United States, not only because the snipers were only targeting people in that area, but also because these children had likely been exposed to more intense local media coverage (Becker-Blease, Finkelhor, and Turner 2008).

In May 2003, Self-Brown et al. (2011) studied the psychological responses of children to the sniper attacks through telephone interviews with 355 parents who had children 2 to 27 years old and had lived in Washington, DC, or its surrounding counties during the sniper attacks. About 32 percent of parents participating in the interviews reported that their children had experienced at least one psychological stress symptom related to the sniper attacks.

There is also evidence to suggest that the shootings took a toll on the psychological well-being of parents and teachers (Schulden et al. 2006; Porter 2010). Using data from a survey of 1,205 adults who had lived in the communities affected by the shootings in October 2002, Schulden et al. (2006) showed that 44 percent of parents had experienced at least one traumatic stress symptom and 7 percent reported symptoms consistent with a diagnosis of post-traumatic stress disorder. Furthermore, the authors found that women who lived within 5 miles of any sniper attack were at greatest risk for traumatic stress.

In summary, there is widespread evidence to suggest the sniper attacks of October 2002 had a negative impact on the psychological well-being of citizens, especially children and those from socioeconomically disadvantaged backgrounds, and those living in neighboring communities. Given the well-documented relationship between psychological well-being and school outcomes (e.g., Carrell and Hoekstra 2010), exposure to these attacks might have also affected student achievement, although this question has not been studied to date. The goal of the present study is to fill this gap in the literature.

## 4. DATA

Academic performance is measured annually at the school level in the form of proficiency rates. These rates measure the percentage of students who score at or above a predetermined "proficiency score" on Standards of Learning (SOL) standardized tests administered each spring in Virginia's public schools. These school-level proficiency rates are made publicly available by the Virginia Department of Education and are based on student performance on SOL tests that are typically administered each May.[9] We focus on third- and fifth-grade proficiency in mathematics and ELA, as these SOL tests have been administered annually by the state since the spring of 1998. Importantly, although the tests themselves have evolved over time, the basic reporting of schools' proficiency rates has not.

9. See www.pen.k12.va.us/testing/achievement_data/archived/index.shtml.

Our primary analysis focuses on the academic years 1997–98 through 2002–03. Henceforth, we refer to academic years by the spring semester (when the tests were administered), so the impact of the sniper attacks on test scores would appear in 2003. The DD identification strategy exploits variation in schools' geographic proximity to the attack locations. We argue this is a plausible measure of the intensity of treatment (i.e., exposure to the sniper attacks), though arguably all children in the state might have been affected via exposure to intense media coverage. Therefore, there may have been spillover effects on the "control" schools that were farther away from the attacks. However, it is important to note that such a bias would work against finding significant effects of these attacks on school proficiency rates, and thus our estimates may be interpreted as lower bounds of the "true" treatment effects. Sensitivity analyses consider various definitions of schools' treatment statuses, or "closeness," to the attacks, and find that the main results are robust to the operationalized definition of "closeness."

Closeness can be defined by either the "commute" or "crow flies" distance between each school's street address and that of the nearest sniper shooting.[10] The results are quite robust to which of these definitions is used to construct measures of "closeness," so we focus on the "crow flies" distance for simplicity. After choosing how to measure the distance between each school and its nearest sniper attack, we then must assume a functional form through which distance enters the econometric model. The preferred baseline model uses a simple binary indicator for "within 5 miles" of at least one shooting. However, as shown in Appendix table A.1, the main results are fairly robust to using alternative definitions using alternative thresholds, multiple categorical indicators (i.e., within 5 miles, 5 to 10 miles, and more than 10 miles), and a continuous quadratic function of miles to the nearest attack. These alternatives yield qualitatively similar results, so we use the "within 5 miles" binary treatment for simplicity.

Our identification strategy assumes that sniper attacks had either no or little impact on children who attended schools relatively far from the attacks. This assumption does not require the proficiency levels of these students to be similar to those of their counterparts who attended schools located in proximity to the shootings. Instead, it requires the proficiency levels to be trending similarly between the two groups of students in the pre-attack period. Indeed, schools that are farther away from the shooting sites are mostly located in rural counties. As a result, the composition of students attending these schools differs in several dimensions from those in schools close to shooting sites, including race, socioeconomic status, and academic achievement. There are also corresponding differences in school characteristics such as school enrollment (size) and student–teacher ratio. While this does not necessarily constitute a problem for our analysis, we exclude schools that are outside a 50-mile radius of all sniper shootings from the analytic sample in an attempt to create a control group that more closely resembles the treatment group. Exclusion of these schools amounts to a conservative approach, if anything, as it would bias our analysis against finding an effect given the likelihood of spillover effects on the control group; however, this turns out to be a moot point, as the main results are robust to the definition of the control group. Finally, eliminating

10. Both types of distances were generated by the Web site freemaptools.com/how-far-is-it-between.htm, which uses an algorithm that evaluates potential driving routes to identify the shortest route between two geocoded addresses for the "commute" distance and latitude and longitude geocodes to compute straight line "as the crow flies" distances.

**Table 1.** Description of Sniper Attacks' Proximities to Virginia (VA) Schools

| # | Date | Fatal | City | State | Distance to Nearest School (mi) | VA Schools within 5 mi | VA Schools within 10 mi |
|---|---|---|---|---|---|---|---|
| 1 | 2 October | Yes | Silver Spring | MD | 9.88 | 0 | 1 |
| 2 | 3 October | Yes | Rockville | MD | 7.08 | 0 | 13 |
| 3 | 3 October | Yes | Rockville | MD | 7.08 | 0 | 14 |
| 4 | 3 October | Yes | Silver spring | MD | 7.07 | 0 | 14 |
| 5 | 3 October | Yes | Kensington | MD | 4.49 | 2 | 72 |
| 6 | 3 October | Yes | Washington | DC | 7.07 | 0 | 33 |
| 7 | 4 October | No | Fredericksburg | VA | 1.20 | 18 | 34 |
| 8 | 7 October | No | Bowie | MD | 18.76 | 0 | 0 |
| 9 | 9 October | Yes | Manassas | VA | 0.28 | 28 | 62 |
| 10 | 11 October | Yes | Fredericksburg | VA | 1.02 | 20 | 34 |
| 11 | 14 October | Yes | Falls Church | VA | 0.71 | 82 | 170 |
| 12 | 19 October | No | Ashland | VA | 0.97 | 5 | 33 |
| 13 | 22 October | Yes | Silver Spring | MD | 10.24 | 0 | 0 |

*Note:* Distances are measured in miles "as the crow flies."

these schools guards against the possibility that proficiency levels of students in rural schools were trending differently than those of relatively more urban schools in the Washington, DC, suburbs, perhaps due to differences in district-level policies. This is not an implausible scenario since district policies may reflect in part the political and cultural preferences of citizens, which are likely to differ significantly between rural and urban communities. Nonetheless, the main results are robust to using alternative cut-offs, such as 40 miles or 60 miles, and to including all Virginia schools in the analytic sample.

We augment the school-level proficiency and "closeness to sniper attack" data with information on time-variant school-level characteristics that are publicly provided in the National Center for Education Statistics' Common Core of Data.[11] Specifically, these variables include total enrollment, percent black, percent Hispanic, percent eligible for free or reduced-price lunch, number of full-time equivalent teachers (FTE), and pupil–teacher ratio. All but the last two variables have been collected since 1998, whereas FTE and pupil–teacher ratios are only available from 1999 forward. We therefore imputed 1998 values of FTE and pupil–teacher ratio, though we also consider models that exclude these two imputed variables and the main results are robust.[12] Importantly, controlling for these time-variant school characteristics in the DD regression models increases the precision of the DD estimates and controls for potentially confounding changes in schools' student and teacher characteristics.

Table 1 shows that although only five of the thirteen sniper shootings occurred in Virginia, the shootings that occurred in Maryland and in Washington, DC, plausibly affected Virginia's public school students as well, given the proximity and overlap in media coverage between Northern Virginia and the areas outside Virginia in which

11. See http://nces.ed.gov/ccd/.
12. Values were imputed as the fitted values of linear regressions containing school fixed effects, linear time trends, observed total enrollment, percent black, percent Hispanic, and percent eligible for free or reduced-price lunch. Results are robust to only controlling for the four school-level characteristics that are observed starting in 1998.

**Table 2.** Descriptive Statistics for School Pass Rates

| | All Schools | | | Schools within 50 miles | | |
|---|---|---|---|---|---|---|
| | All (1) | Outside 5 miles (2) | Within 5 miles (3) | All (4) | Outside 5 miles (5) | Within 5 miles (6) |
| English 3 | 63.36 | 63.02 | 67.58*** | 67.25 | 67.19 | 67.58 |
| | (17.19) | (17.37) | (14.09) | (17.31) | (17.88) | (14.09) |
| | [6,312] | [5,837] | [475] | [2,882] | [2,407] | [475] |
| English 5 | 72.29 | 72.04 | 75.38*** | 74.86 | 74.76 | 75.38 |
| | (16.45) | (16.65) | (13.44) | (16.76) | (17.33) | (13.44) |
| | [6,284] | [5,809] | [475] | [2,913] | [2,438] | [475] |
| Math 3 | 73.23 | 72.91 | 77.19*** | 76.09 | 75.87 | 77.19 |
| | (16.68) | (16.94) | (12.39) | (16.70) | (17.42) | (12.39) |
| | [6,310] | [5,836] | [474] | [2,879] | [2,405] | [474] |
| Math 5 | 60.84 | 60.39 | 66.37*** | 65.09 | 64.84 | 66.37 |
| | (21.85) | (22.08) | (17.87) | (21.49) | (22.12) | (17.87) |
| | [6,283] | [5,810] | [473] | [2,909] | [2,436] | [473] |

*Notes:* Standard deviations are reported in parentheses. Sample sizes are reported in brackets. "Within 'x' miles" refers to schools' proximity to the nearest sniper attack.

***Statistically significant differences between treated (within 5 miles) and control groups at the 99 percent confidence level.

sniper attacks occurred. For example, the 3 October sniper shooting in Kensington, Maryland, was within 5 miles of two Virginia public schools and within 10 miles of seventy-two Virginia public schools. Similarly, all but two of the Maryland attacks were within 10 miles of at least one Virginia public school and four of the Maryland attacks were within 10 miles of more than ten Virginia public schools. Thus, table 1 suggests the earlier attacks that occurred in Maryland and in Washington, DC, potentially affected residents of Virginia and contribute to the geographic variation in "treatment status."

Table 2 summarizes the proficiency rates both for the overall sample and separately by distance to the nearest sniper attack. Proficiency rates ranged from about 60 percent to 80 percent. To put these numbers in perspective, the thresholds for making AYP in Virginia in the first two years of NCLB were 61 in ELA and 59 in mathematics (Virginia Board of Education 2010). Interestingly, columns 2 and 3 show that there are statistically significant differences between "treated" and "control" schools in average proficiency rates. This suggests that there were some systematic differences between schools by schools' proximities to an attack, which is unsurprising as the attacks were relatively close to the Washington, DC, metropolitan area. These differences further motivate our decision to restrict the sample to schools within 50 miles of at least one attack and highlight the importance of accounting for preexisting differences between "treated" and "control" schools in the econometric model via school fixed effects.

Columns 4–6 of table 2 present the same summary statistics for the analytic sample of schools within 50 "as the crow flies" miles of at least one sniper attack. It is immediately obvious that these control schools more closely resemble the treated schools, as proficiency gaps between treated and control schools tend to be smaller and lose their statistical significance. This is the analytic sample used in the main analyses.

Table 3 similarly summarizes schools' distances to the sniper attacks and the time-variant school characteristics observed in the Common Core of Data. A nontrivial number of Virginia public schools were proximate to at least one sniper attack. The average

**Table 3.** Descriptive Statistics for School Characteristics

| | All (1) | Treated (2) | Control (3) |
|---|---|---|---|
| Miles | 15.73 | 2.93 | 18.23*** |
| | (11.88) | (1.15) | (11.42) |
| Within 5 miles | 0.16 | 1.00 | 0.00*** |
| Within 10 miles | 0.37 | 1.00 | 0.25*** |
| Enrollment | 566.53 | 544.18 | 570.88 |
| | (195.16) | (163.43) | (200.49) |
| % black | 0.25 | 0.16 | 0.26*** |
| | (0.27) | (0.11) | (0.28) |
| % Hispanic | 0.08 | 0.21 | 0.06*** |
| | (0.12) | (0.17) | (0.08) |
| % FRPL | 0.29 | 0.33 | 0.28* |
| | (0.24) | (0.21) | (0.24) |
| FTE | 37.89 | 40.90 | 37.31*** |
| | (13.51) | (13.13) | (13.51) |
| Pupil-teacher ratio | 15.65 | 13.34 | 16.10*** |
| | (9.32) | (2.67) | (10.06) |
| *N* | 2,878 | 460 | 2,418 |

*Notes:* Standard deviations are reported in parentheses. Sample restricted to schools within 50 miles “as the crow flies” of at least one attack. FRPL: free or reduced-price lunch eligible; FTE: full time equivalent teachers.

***Statistically significant differences between treated (within 5 miles) and control groups at the 99 percent confidence level.

school in the analytic sample (within 50 miles of at least one sniper attack) was about 16 miles from at least one sniper attack. About 16 percent of elementary schools were within 5 miles “as the crow flies” of a sniper attack and 37 percent were within 10 miles. There are several differences between treated and control elementary schools, as defined by the “five-mile” treatment. Treated schools have smaller enrollments, but this difference is not significantly different from zero. Racial, ethnic, and socioeconomic differences in enrollments are statistically significant, however, because treated schools’ enrollments are less black, more Hispanic, and more disadvantaged. Despite being smaller, on average, treated elementary schools have significantly more FTE teachers and significantly lower pupil–teacher ratios.

## 5. ECONOMETRIC MODEL

Our goal is to estimate the impact of exposure to the Beltway Sniper attacks on academic achievement. We do so by specifying the following reduced-form empirical model:

$$y_{st} = \beta_0 + \beta_1 X_{st} + \beta_2 Close_s \times d_{2003} + \lambda_t + \delta_s + \gamma t District_s + \varepsilon_{st}, \quad (1)$$

where $y_{st}$ is the proficiency rate of school $s$ in academic year $t$ in a particular grade and subject.[13] The time-varying school characteristics described in the previous section are represented by the vector $X_{st}$. The variable $Close_s$ is a binary indicator equal to 1 if the

13. We estimated equation 1 using the natural logarithm of the outcome variables instead of levels. These results are similar to those presented in our paper and are available from the authors upon request.

school is within 5 miles of any shooting location, and zero otherwise.[14] The binary indicator $d_{2003}$ equals 1 in the academic year 2003, which is the treatment year in which the sniper attacks occurred, and zero otherwise. Year fixed effects ($\lambda_t$) control for any secular time trends in the outcome variables and year-specific statewide shocks to academic achievement associated with, for example, national- or state-level policies. School fixed effects ($\delta_s$) account for any unobserved time-invariant heterogeneity between schools in Virginia. We estimate equation 1 by ordinary least squares.[15] In all analyses, standard errors are robust to clustering at the school level, making statistical inference robust to arbitrary forms of both heteroskedasticity and serial correlation within schools over time.[16]

The coefficient of interest is $\beta_2$, which represents the average effect on school proficiency of being within 5 miles of a sniper attack. A causal interpretation of the estimate of $\beta_2$ in equation 1 hinges on the "parallel trends" assumption required by the DD method. Intuitively, this means that although there may be pre-existing differences between "treated" and "control" schools, there are no pre-existing differential trends between "treated" and "control" schools. We address this assumption in two ways. First, we follow Marcotte and Hemelt (2008) in explicitly relaxing the "parallel trends" assumption by controlling for school district–specific linear time trends ($\gamma\, tDistrict$). Therefore, our empirical specification controls for any unobservable district-level characteristics and policies that are trending linearly over time and predict proficiency rates, which is potentially important given that policies and decisions regarding school closures are typically made at the district level (Marcotte and Hemelt 2008).[17] Second, we directly test the "parallel trends" assumption by estimating an event-study specification that allows the treatment to have an effect in years prior to the sniper attacks. If these placebo effects are statistically significant, particularly in the year before the sniper attacks, we would worry that the "parallel trends" assumption fails and that significant estimates of $\beta_2$ in the baseline equation 1 are spuriously driven by pre-existing

14. Appendix table A.1 shows the main findings are robust to using alternative specifications of "closeness," such as a continuous quadratic function of the school's distance to the closest attack site, using alternative thresholds to define a binary "closeness" indicator, and using a pair of mutually exclusive categorical indicators for "within five miles" and "five to ten miles," with the omitted reference category being "more than ten miles from an attack."
15. We also estimate the models by weighted least squares using schools' grade-specific enrollments as weights (Solon, Haider, and Wooldridge 2015). These estimates are qualitatively similar to, and reported alongside, the unweighted estimates in table 4.
16. Clustering at the district level yields nearly identical statistical inference, which is unsurprising because schools are nested in districts and all models condition on school fixed effects and district-specific time trends. We prefer clustering at the school level because the treatment varies at the school level.
17. Allowing for quadratic district-specific time trends yields qualitatively similar results. Note that an alternative approach could be to estimate models with school-specific linear trends. However, with about 540 elementary schools in the analytic sample and only 6 years of data, we lose a commensurate number of degrees of freedom by doing so. As a result, estimates of $\beta_2$ in models that condition on school-specific linear trends are less precise, though generally of the same sign as those obtained from the estimation of equation 1 and its district trend analog. As an alternative attempt to account for the possibility of differential trends at the school level, we also estimate our models controlling for two-way interactions of each of our school-level control variables and year indicators. If the year-to-year changes in test scores at the school level are highly correlated with changes in school level characteristics such as enrollment, pupil–teacher ratio, and the racial composition of the schools, then these interactions may capture the changes in school level trends in a flexible way. The results from this specification are similar to the main results presented in the paper and are available from the authors upon request.

differential trends in the treated schools. It is reassuring, then, that in the results presented below event-study estimates provide evidence that is consistent with the sniper attacks having a causal effect on schools' math and ELA proficiency rates.

Finally, we estimate equation 1 separately by school type to test for heterogeneous effects, as there are several reasons why schools serving different student populations might be differentially affected by community traumatic events. Specifically, because the aggregate data do not distinguish between proficiency rates of different student subgroups, we divide schools into terciles based on the percentage of total 2003 enrollment that is black, and the percentage of total 2003 enrollment that is eligible for free or reduced-price lunch (FRPL). There are at least two reasons to expect that the academic achievement of socioeconomically disadvantaged and racial minority students was disproportionately harmed by the disruptions and stress caused by the sniper attacks. First, as discussed in section 2, parental behaviors have the potential to mitigate the impact of community traumatic events on children (Buka et al. 2001; Plybon and Kliewer 2001). Given the large research literature documenting the differences by socioeconomic status (SES) in both the quality and quantity of time parents spend with school-age children (e.g., Guryan, Hurst, and Kearney 2008; Kalil, Ryan, and Corey 2012), it is plausible that high-SES parents had the resources necessary to provide support at home and outside the traditional school day to help children cope with the trauma. Second, recent research on the effects of weather-induced school closures and student absences on academic achievement finds, at least in certain subjects and grade levels, the harmful effects of lost instructional time are greater in poorer schools (Marcotte and Hemelt 2008; Goodman 2014). Given that school closures and student absences are potential mechanisms through which the sniper attacks affected achievement, the harmful effects of sniper-induced absences and school closures might be greater in disadvantaged schools, if such schools are less able to provide the appropriate counseling and, more generally, struggle to solve the coordination problem inherent in public education (i.e., Lazear 2001). Moreover, given that absenteeism rates are higher among disadvantaged students (Gershenson, Jacknowitz, and Brannegan 2017), another potential source of heterogeneity in the sniper attacks' effects on academic achievement is through larger effects of the attacks on student absences in low-SES schools.

## 6. RESULTS

Our main results are presented in table 4. Each cell in table 4 contains the estimate of $\beta_2$ in a unique regression, which measures the effect of being within 5 miles of a sniper attack. We present estimates separately for both the ELA and math proficiency rates for each of grades 3 and 5. Columns 1 and 2 report estimates of $\beta_2$ from equation 1 without and with time-variant school characteristics, respectively. If our identification strategy is valid, then controlling for exogenous determinants of academic test scores should not influence the estimate of $\beta_2$.

Column 1 of table 4 shows that being within a 5-mile radius of a sniper attack is associated with lower pass rates in both subjects for both grade levels. Furthermore, the estimated effects are statistically significant for three of the four models and the magnitudes are sizeable, ranging from about 1.5 to 3 percentage points. Taking the mean pass rates in schools outside the 5-mile radius presented in column 5 of table 2 as a

**Table 4.** Estimates of Effect of Proximity to Sniper Attacks on School Pass Rates

| | No Controls (1) | Baseline (2) | Baseline Weighted (3) | I-95 Sample (4) | Common Support Sample (5) | Nearest-Neighbor Sample (6) | Pentagon Sample (7) |
|---|---|---|---|---|---|---|---|
| English 3 | −2.100 | −1.924 | −1.265 | −1.110 | −3.303 | −3.732 | −2.640 |
| | (1.114)* | (1.087)* | (1.242) | (1.064) | (0.959)*** | (1.041)*** | (1.071)** |
| *N* | 2,851 | 2,851 | 2,816 | 2,243 | 2,263 | 1,372 | 2,880 |
| English 5 | −1.423 | −1.376 | −1.160 | −1.726 | −1.012 | −1.166 | −1.205 |
| | (1.155) | (1.167) | (1.103) | (1.190) | (1.044) | (1.117) | (1.224) |
| *N* | 2,881 | 2,881 | 2,806 | 2,269 | 2,500 | 1,316 | 2,911 |
| Math 3 | −2.309 | −2.624 | −2.078 | −2.744 | −2.521 | −1.705 | −2.258 |
| | (1.019)** | (0.964)*** | (1.051)** | (0.958)*** | (0.858)*** | (0.949)* | (0.848)*** |
| *N* | 2,848 | 2,848 | 2,816 | 2,242 | 2,471 | 1,360 | 2,877 |
| Math 5 | −2.945 | −2.974 | −2.591 | −3.703 | −2.522 | −3.000 | −2.183 |
| | (1.336)** | (1.350)** | (1.386)* | (1.384)*** | (1.265)** | (1.340)*** | (1.257)* |
| *N* | 2,878 | 2,878 | 2,807 | 2,264 | 2,372 | 1,377 | 2,907 |
| Trends | Yes | Yes | Yes | Yes | No | No | Yes |
| Controls | No | Yes | Yes | Yes | No | No | Yes |

*Notes:* Each cell reports the interaction term (treatment effect) from a distinct regression. Standard errors are reported in parentheses and are robust to clustering at the school level. School controls in columns 2–4 include full-time equivalent teachers, student–teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch eligible. All models control for school and year fixed effects. Columns 1–4 and 7 include linear district time trends. Sample contains data from 1998 to 2003 school years (6 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples in all columns except for column 7. The treatment term indicator in column 7 equals one if the school was within 5 miles of the Pentagon in 2002 or was within 5 miles of a sniper attack in 2003. The samples in columns 5 and 6 are restricted based on predicted propensity scores that reflect the propensity to be within 5 miles of a shooting. Propensities were estimated by fully flexible logit models that included lagged proficiency rates. In column 5, the analytic sample is restricted to the area of common support. In column 6, the analytic sample is restricted to the set of treated schools and five nearest-neighbor control school matches.

***Statistically significant at the 99 percent confidence level; **statistically significant at the 95 percent confidence level; *statistically significant at the 90 percent confidence level.

basis, these estimates translate into effect sizes of about 2 percent for fifth-grade ELA and 4.5 percent for fifth-grade math.

Column 2 shows that the estimates are robust to controlling for time-variant school characteristics. This supports the validity of our identification strategy, as it suggests the other known determinants of academic proficiency are orthogonal to the within-school variation in exposure to sniper attacks. Furthermore, Appendix table A.1 shows that the patterns observed in table 4 are fairly robust to how "closeness" to a sniper attack is measured, because using alternative thresholds, as well as continuous and nonparametric specifications, suggests schools closer to sniper attacks experienced significant declines in proficiency rates in 2003, particularly in math, relative to schools that were farther away.

As suggested by Solon, Haider, and Wooldridge (2015), weighted least squares estimates of the baseline model that weight by schools' grade-specific enrollments are reported in column 3. These estimates are quite similar to the unweighted estimates reported in column 2. Viewed as a diagnostic, this similarity suggests that the model is correctly specified. In subsequent analyses we focus on the unweighted estimates because grade-specific enrollments are missing for several schools and because the ordinary least squares estimates tend to be more precise. The latter is unsurprising, as it suggests the underlying student-level error terms are correlated within schools (Solon, Haider, and Wooldridge 2015). Accordingly, as discussed in section 5, all inference is conducted using cluster-robust standard errors, which are also robust to arbitrary forms of heteroskedasticity.

It is important to remember that the sniper shootings primarily occurred along the I-95 corridor. One potential concern with our identification strategy is that there was something peculiar about schools located along the I-95 corridor that caused the proficiency rates in these schools to decrease in the year of the sniper attacks. Thus far, control schools along I-95 are grouped together with other control schools that were between 5 and 50 miles of a sniper attack. As a result, we could be obtaining the partial impact of some confounding event that affected all schools along the I-95 corridor that had nothing to do with the sniper attacks. Although we do not have a specific confounding event or factor that differentially affected schools along I-95 in 2003 in mind, we nevertheless guard against this possibility by estimating our main models using an analytic sample restricted to schools in districts along the I-95 corridor. Doing so allows us to conduct the analysis with a more homogenous sample of schools that is less susceptible to potentially confounding factors that violate the parallel trends identifying assumption. If the estimates obtained in column 2 of table 4 were indeed caused by the sniper attacks, analyses of the I-95 sample should yield results similar to those obtained in the full sample. Accordingly, we reestimate our baseline specification using a restricted analytic sample of schools located along the I-95 corridor. Specifically, the "I-95 sample" includes all schools in the twenty school divisions (districts) through which I-95 passes and the city/town school divisions that are within 10 miles of I-95.[18] As shown in column 4 of table 4, the estimates from this sample are very similar to those in column 2. Notably, the estimates for third- and fifth-grade math exams are statistically significant and similar in size to those for the baseline sample in column 2, despite significant reductions in the sample size. We interpret this finding as evidence against an argument that our results are driven by some confounding factor related to treated schools' proximity to I-95.

Alternatively, we could restrict the control group to observationally similar, similarly trending schools using a matching-on-observables procedure. We make two such restrictions using propensity scores estimated by a flexible logit model that includes current school characteristics (the $X_{st}$ in equation 1) and cubics in three lags of the proficiency-rate outcomes. We use these estimated propensity scores to restrict the analytic sample to schools in the area of common support, and to the five nearest neighbors of each treated school, in columns 5 and 6, respectively. We then estimate the baseline model on these matched samples, without district trends and time-varying $X$, as the matching procedure explicitly matched on $X$ and pre-existing trends in $y$. Once again, the point estimates derived from the "matched sample" analyses in columns 5 and 6 closely resemble the baseline estimates reported in column 2. This is reassuring, yet

18. The fourteen county school divisions are Greensville, Emporia, Sussex, Prince George, Dinwiddie, Chesterfield, Henrico, Hanover, Caroline, Spotsylvania, Stafford, Prince William, Arlington, and Fairfax. The six city/town school divisions are Petersburg, Colonial Heights, Richmond, Fredericksburg, Falls Church, and Alexandria. Because seven of the county school divisions contain schools with catchment areas that are more than ten miles from I-95, we also verify that these results are robust to further restricting the "I-95 sample" to exclude such schools.

unsurprising, as the district trends in the baseline model already control for possible differences between treated and control schools' trends.

Finally, the impact of traumatic events that occurred elsewhere in the country during our analysis period would be captured by our year fixed effects. One potential exception is the terrorist attack on the Pentagon that occurred on 11 September 2001.[19] Given the proximity of the Pentagon to several of the Virginia communities affected by the sniper attacks that occurred almost one year later, it is possible that persistent psychological symptomology of trauma associated with the 11 September 2001 attacks, and with that on the Pentagon in particular, might confound our analysis of the 2002 sniper attacks. In other words, the effects of the sniper attacks documented herein might be at least partly attributable to the Pentagon attack. To provide further insights into the issue, we consider a version of equation 1 in which the treatment is redefined as being within a 5-mile radius of the sniper attacks in October 2002 or within a 5-mile radius of the Pentagon in 2001. In addition to providing evidence on the sensitivity of our main results, this analysis is interesting in its own right, as it provides evidence on the average impact of both the Pentagon and sniper attacks. As shown in column 7 of table 4, these estimates are quite similar in size and precision to our preferred baseline estimates.

In summary, the evidence presented in table 4 indicates that being within a 5-mile radius of a sniper attack site is associated with a statistically significant decrease in proficiency on third-grade ELA and third- and fifth-grade math tests. This result is consistent with previous research on the harmful effects of disruptions to learning, which finds that weather-related school closures and exposure to acute incidents of extreme violence have relatively larger effects on achievement in the elementary grades (Marcotte and Hemelt 2008; Sharkey et al. 2014). Moreover, it is important to emphasize that the most robust estimates are obtained for math proficiency. This is consistent with the previous literature on the efficacy of school inputs that routinely shows math achievement scores are more sensitive than ELA scores to shocks to school environments (e.g., Hanushek and Rivkin 2010). Currie and Thomas (2001) speculate this may be because children are more apt to learn reading skills at home, which suggests, to the extent that the sniper attacks caused absences, school closures, and displaced instructional time during school days, one would expect to see larger effects on math achievement.

Next we estimate an event-study version of equation 1 to trace out the trends in proficiency rates, separately for treated and control schools, year-by-year for the periods leading up to the year of the sniper shootings. As discussed in section 5, this provides a simple test of the "parallel trends" assumption required for consistency by the DD specification given in equation 1. Formally, this is done by augmenting equation 1 to include interactions between each of the year indicators with the *Close* treatment indicator. Event study estimates of specifications that control for time-variant school

19. The attack on the Pentagon was part of a larger, coordinated terrorist attack by the terrorist group Al-Qaeda on the United States. On 11 September 2001, two planes crashed into the World Trade Center buildings in New York City. On the same day, a third plane crashed into the Pentagon causing a partial collapse of the headquarters. A fourth plane, which was heading to Washington, DC, crashed in a field in Pennsylvania. A total of 2,996 individuals were killed in the attacks. The total number of casualties at the Pentagon crash was 189, including 59 passengers, 125 people who were in the building at the time, and 5 terrorists. As the deadliest terrorist attack ever carried out in the United States, the events of 11 September 2001 caused a tremendous amount of fear and anxiety.

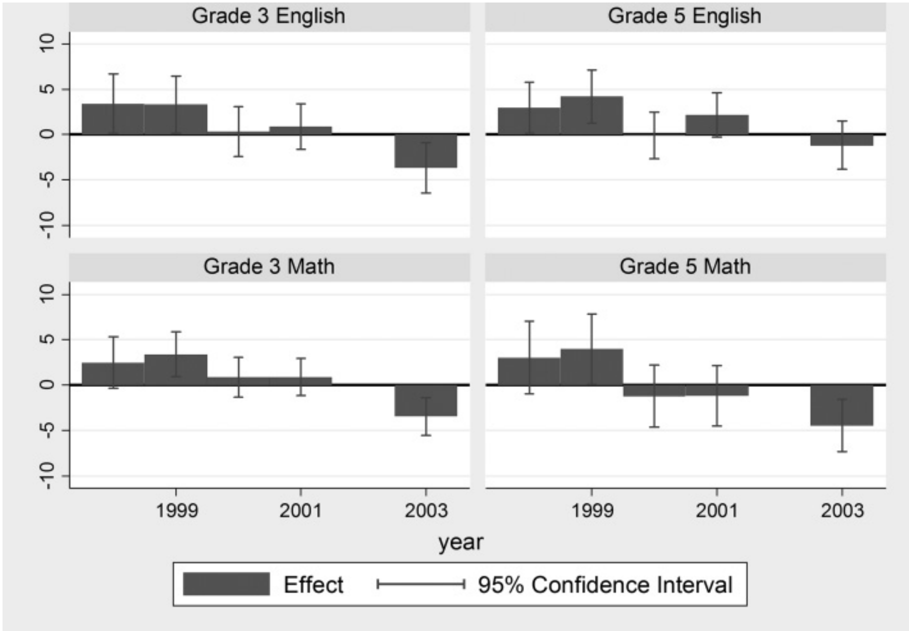
**Table 5.** Event Study Estimates of Effect of Proximity to Sniper Attacks on School Pass Rates

| Outcome | ELA 3 (1) | ELA 5 (2) | Math 3 (3) | Math 5 (4) |
|---|---|---|---|---|
| 1998 | −24.284 | −2.973 | −19.877 | −23.008 |
| | (0.815)*** | (0.677)*** | (0.683)*** | (0.854)*** |
| 1999 | −15.774 | −3.345 | −15.176 | −19.807 |
| | (0.617)*** | (0.602)*** | (0.575)*** | (0.707)*** |
| 2000 | −14.548 | −5.207 | −9.824 | −5.997 |
| | (0.547)*** | (0.514)*** | (0.499)*** | (0.648)*** |
| 2001 | −9.378 | −2.579 | −4.174 | −3.829 |
| | (0.568)*** | (0.552)*** | (0.465)*** | (0.621)*** |
| 2002 | – | – | – | – |
| 2003 | 1.954 | 4.496 | 5.642 | 3.771 |
| | (0.557)*** | (0.580)*** | (0.508)*** | (0.684)*** |
| 1998 × *Close* | −0.237 | 1.561 | −0.283 | 1.142 |
| | (1.796) | (1.643) | (1.443) | (2.268) |
| 1999 × *Close* | 0.693 | 3.240 | 1.447 | 2.695 |
| | (1.669) | (1.598)** | (1.275) | (2.129) |
| 2000 × *Close* | −1.320 | −0.659 | −0.381 | −1.825 |
| | (1.485) | (1.349) | (1.177) | (1.729) |
| 2001 × *Close* | 0.139 | 1.980 | 0.305 | −1.250 |
| | (1.268) | (1.265) | (1.031) | (1.705) |
| 2002 × *Close* | Omit | | | |
| 2003 × *Close* | −2.097 | −0.478 | −2.447 | −3.495 |
| | (1.388) | (1.392) | (1.095)** | (1.531)** |
| School-years (*N*) | 2,851 | 2,881 | 2,848 | 2,878 |
| Schools (clusters) | 513 | 546 | 511 | 541 |

*Notes:* Standard errors are reported in parentheses and are robust to clustering at the school level. Analytic samples are restricted to schools within 50 miles of at least one sniper shooting. All models control for school and year fixed effects, district specific linear time trends, and the following time-variant school controls: full-time equivalent teachers, student–teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch eligible. Sample contains data from 1998 to 2003 school years (6 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples. ELA: English language arts.

***Statistically significant at the 99 percent confidence level; **statistically significant at the 95 percent confidence level.

characteristics are presented in table 5. Consistent with our earlier findings, the estimates of the coefficients on the interaction between the *Close* and 2003 (treatment year) indicators are negative for all four tests and statistically significant for math in both grades. Furthermore, these treatment effect estimates are larger in magnitude than all of the other interaction terms. Intuitively, the goal of the event study analysis is to examine the differences between treatment and control schools in the years leading up to 2003, the academic year in which the sniper attacks took place. This is most easily accomplished visually, so we plot the interaction terms reported in table 5, along with their 95 percent confidence intervals, in figure 2. As illustrated in figure 2, there is a clear overall pattern of a statistically significant divergence in 2003 from the pre-sniper attack period trends. The aforementioned pattern is most pronounced for third-grade English and third- and fifth-grade math scores. Furthermore, the estimates on the year indicators suggest that average pass rates had been increasing consistently over the analysis period. Interpreting the estimates on the interaction terms in conjunction




*Notes:* The omitted year is 2002. Brackets represent 95 percent confidence intervals, robust to clustering at school level. The bars represent the estimated interaction terms reported in Table 5, from event study models that control for time-varying school characteristics and school and year fixed effects.

**Figure 2.** Event Study Estimates of the Impact of Sniper Attacks on Pass Rates

with the individual year indicators supports the hypothesis that the sniper attacks decreased proficiency rates in nearby schools.

Given the evidence presented to this point, which suggests that the sniper attacks caused a statistically significant decrease in school proficiency rates in third-grade ELA and third- and fifth-grade math, natural questions to consider are whether the trauma was amplified in schools that were close to multiple shootings and whether these effects persisted into subsequent school years. Regarding the former, eleven schools were within 5 miles of two sniper attacks. The treatment in these schools was likely particularly intense. To formally test this hypothesis, we augment the baseline model to code *Close* as a vector of categorical indicators for the number of nearby attacks, omitting "zero attacks" as the reference category. These results are presented in table 6. Here, we see evidence of significant dosage effects for each subject: The effect of being within 5 miles of two attacks is two to seven times as large as being within 5 miles of one attack and is strongly statistically significant in each case. The treatment indicators are jointly significant for each subject and the effect of being within 5 miles of two attacks is significantly larger than the effect of being within 5 miles of one attack in three of four cases. The presence of such dosage results are consistent with the sniper attacks having had a causal impact on student achievement and suggests that more severe community traumatic events cause proportionally greater harm to student learning.

An analysis of the persistence of such effects is possible because the SOL tests continued in a similar form for two additional years following the academic year in which

**Table 6.** Dosage Effects of Sniper Attacks on School Pass Rates

| Subject | English 3 (1) | English 5 (2) | Math 3 (3) | Math 5 (4) |
|---|---|---|---|---|
| 2003 × *1 Attack* | −1.196 | −0.887 | −2.290 | −2.690 |
| | (1.118) | (1.214) | (1.019)** | (1.419)* |
| 2003 × *2 Attacks* | −7.729 | −5.427 | −5.390 | −5.301 |
| | (2.104)*** | (2.067)*** | (1.545)*** | (1.997)*** |
| Joint Sig. (*p*) | 0.001 | 0.032 | 0.001 | 0.016 |
| Difference (*p*) | 0.003 | 0.035 | 0.060 | 0.206 |
| *N* | 2,851 | 2,881 | 2,848 | 2,878 |

*Notes:* The omitted category is 2003 × *0 Attacks*, where *Attacks* counts the number of attacks that occurred within 5 miles of the school. Standard errors in parentheses are robust to clustering at the school level. Analytic samples restricted to schools within 50 miles of at least one sniper shooting. School controls include full-time equivalent teachers, student–teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch eligible. All models control for school and year fixed effects as well as district-specific linear time trends. Sample contains data from 1998 to 2005 school years (8 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples.

***Statistical significance at the 99 percent confidence level; **statistical significance at the 95 percent confidence level; *statistical significance at the 90 percent confidence level.

the sniper attacks occurred. Accordingly, table 7 presents estimates of augmented baseline and dosage models that utilize data through 2005. These models include the usual *Close* × $d_{2003}$ interaction term and *Close* × *Post* interaction terms, where *Post* equals 1 if the academic year is 2004 or 2005, and zero otherwise. The specification estimated in panel A of table 7 is otherwise identical to the baseline specification estimated in table 4. These results are consistent with the sniper attacks having had a negative impact on students' academic achievement in 2003. In particular, the estimated effects of being within 5 miles of a sniper attack are uniformly negative and are statistically significant in three subjects: third-grade ELA and third- and fifth-grade math. However, these effects do not persist, as the estimated effects of proximity to a sniper attack in subsequent years tend to be statistically indistinguishable from zero and small in magnitude. It is perhaps unsurprising that we detect no persistent effects of the sniper attacks on proficiency rates in subsequent years across all schools—as the attacks occurred in October of 2002 and the 2004 tests were administered in May 2004, more than 18 months later—and the majority of treated schools were exposed to only one attack.

However, the dosage results reported in table 6 suggest that if the impacts persisted anywhere, it would likely have been in the most intensely treated schools that were close to multiple sniper attacks. Panel B of table 7 tests this hypothesis by allowing the persistence effects to vary with intensity of treatment. Indeed, these results show some evidence that the effects did persist in subsequent years, particularly in math, in the most intensely treated schools. Like in panel A, the dosage-persistence results reported in panel B show no evidence of persistent effects in schools that were close to only one shooting, and the persistent effects of exposure to two shootings are less precisely estimated than those in the year of the attacks.

Once again, the results presented in table 7 are consistent with the sniper attacks having had a causal effect on student achievement immediately following the attacks

**Table 7.** Persistence in Effect of Sniper Attacks on School Pass Rates

| Subject | English 3 (1) | English 5 (2) | Math 3 (3) | Math 5 (4) |
|---|---|---|---|---|
| Panel A: Exposure Model | | | | |
| 2003 × *Close* | −2.609 | −1.518 | −2.341 | −2.802 |
| | (1.003)*** | (1.067) | (0.898)*** | (1.255)** |
| 2004/5 × *Close* | 1.318 | 2.370 | 0.663 | −0.348 |
| | (1.133) | (1.202)** | (1.152) | (1.333) |
| Difference (*p*) | 0.001 | 0.0001 | 0.001 | 0.054 |
| *N* | 3,835 | 3,877 | 3,835 | 3,876 |
| Panel B: Dosage Model | | | | |
| 2003 × *1 Attack* | −1.774 | −1.215 | −2.244 | −2.657 |
| | (1.036)* | (1.119) | (0.949)** | (1.330)** |
| 2003 × *2 Attacks* | −9.085 | −4.521 | −3.772 | −4.532 |
| | (1.974)*** | (1.904)** | (1.580)** | (1.944)** |
| 2004/5 × *1 Attack* | 1.580 | 2.932 | 1.254 | 0.162 |
| | (1.163) | (1.243)** | (1.167) | (1.348) |
| 2004/5 × *2 Attacks* | −1.471 | −3.151 | −4.966 | −5.342 |
| | (1.948) | (1.756)* | (2.174)** | (3.032)* |
| Joint Sig. of 2004–05 interactions (*p*) | 0.183 | 0.002 | 0.019 | 0.183 |
| Difference in 1*A* (*p*) | 0.005 | 0.0001 | 0.0003 | 0.033 |
| Difference in 2*A* (*p*) | 0.0002 | 0.499 | 0.574 | 0.808 |
| *N* | 3,835 | 3,877 | 3,835 | 3,876 |

*Notes:* In panel A, *Close* is a binary indicator for being within 5 miles of at least one attack. In panel B, the omitted category is 2003 × *0 Attacks*, where *Attacks* counts the number of attacks that occurred within 5 miles of the school. Standard errors in parentheses are robust to clustering at the school level. Analytic samples restricted to schools within 50 miles of at least one sniper shooting. School controls include full-time equivalent teachers, student–teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch eligible. All models control for school and year fixed effects as well as district-specific linear time trends. Sample contains data from 1998 to 2005 school years (8 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples.

***Statistical significance at the 99 percent confidence level; **statistical significance at the 95 percent confidence level; *statistical significance at the 90 percent confidence level.

that persisted in subsequent school years for the subset of schools that were nearby two attacks. That the effects were not universally persistent is a comforting finding in the sense that the negative impacts associated with the sniper attacks were relatively short-lived for the majority of students. Even though it may be possible to reverse the harmful impacts of community traumatic events on student achievement, doing so would still come at a cost given the private parental and public resources that need to be reallocated toward remedying these problems. Therefore, efficiency losses associated with these attacks should not be overlooked. Also, while the effects on test scores may have faded out, effects on socioemotional outcomes might persist. Chetty et al. (2011) find that although effects of primary school classroom quality on test scores “fade out” quickly, effects on noncognitive measures in later grades, and on earnings in adulthood, persist.

### Heterogeneity in the Sniper Effects

Finally, we conclude our analysis with an investigation of potential heterogeneity in the effects of the community trauma on school proficiency rates associated with the 2002

**Table 8.** Heterogeneity in Effects of Proximity (5 miles) to Sniper Attacks on School Pass Rates

| Sample | Bottom Tercile FRPL Enrollment | Top Tercile FRPL Enrollment | Bottom Tercile Black Enrollment | Top Tercile Black Enrollment |
|---|---|---|---|---|
| Outcome | (1) | (2) | (3) | (4) |
| English 3 | −1.570 | −3.107 | −0.206 | −2.391 |
| | (1.511) | (2.129) | (1.422) | (1.689) |
| English 5 | 1.026 | −3.803 | 0.424 | −3.989 |
| | (1.279) | (2.456) | (1.216) | (2.013)** |
| Math 3 | −1.248 | −3.965 | 0.855 | −4.044 |
| | (1.313) | (2.157)* | (1.408) | (1.680)** |
| Math 5 | −1.044 | −5.336 | −0.779 | −4.787 |
| | (1.700) | (2.823)* | (1.470) | (2.270)** |
| School Level controls | Yes | Yes | Yes | Yes |
| School & year FE | Yes | Yes | Yes | Yes |
| District trends | Yes | Yes | Yes | Yes |

*Notes:* Each cell reports the interaction term (treatment effect) from a distinct regression. Standard errors are reported in parentheses and are robust to clustering at the school level. Sample sizes are reported in brackets. Analytic samples restricted to schools within 50 miles of at least one sniper shooting. School controls include full-time equivalent teachers, student-teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch (FRPL) eligible. All models control for school and year fixed effects (FE) as well district-specific linear time trends. Sample contains data from 1998 to 2003 school years (6 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples. The percent-FRL terciles are 18 and 47. The percent-black terciles are 9 and 34.

**Statistical significance at the 95 percent confidence level; *statistical significance at the 90 percent confidence level.

sniper attacks. As discussed above, this analysis is motivated by the common finding in the literature on the psychological effects of community traumatic events that signs of trauma are disproportionately concentrated among racial minority and socioeconomically disadvantaged children (Shannon et al. 1994; Becker-Blease, Finkelhor, and Turner 2008; Neria, Nandi, and Galea 2008). To answer this question, we sorted schools by the percentage of students in 2003 who were eligible for FRPL and the percentage of students who were black. Then we divided each distribution into three equal parts and estimated the baseline model separately for schools in the bottom and top terciles. The bottom terciles contain relatively advantaged schools and the top terciles contain relatively disadvantaged schools.

Columns 1 and 2 of table 8 report baseline estimates for schools in the bottom and top terciles of the FRPL distribution, respectively. Based on previous research, we expect the effects of the sniper attacks on proficiency rates to be more pronounced among the relatively poorer schools in column 2. Indeed, this is exactly what we see: Point estimates for the bottom tercile sample in column 1 are relatively small in magnitude and indistinguishable from zero whereas those for the top tercile of the FRPL distribution reported in column 2 are negative, larger in magnitude, and more precisely estimated. Reductions in the poorer (top tercile) schools' proficiency rates caused by the sniper attacks are large—about twice the size of the baseline estimates that restricted the effect to be homogeneous for all schools—at about 5 percentage points for each ELA and math test.

The estimates reported in columns 3 and 4 of table 8 reinforce the notion that the adverse effects of trauma caused by the sniper attacks fell disproportionately on children from historically disadvantaged backgrounds. In particular, the harmful effects of proximity to the sniper attacks are significantly larger in schools that serve predominantly black student populations, which are similar in size to the effects observed in the relatively poor schools. None of the estimates in column 3, which shows estimates for schools at the bottom tercile in black enrollment, are meaningful either economically or statistically. In contrast, the effects are much larger in magnitude and statistically significant in three out of four outcome models in column 4, which shows the estimates for schools that predominantly serve black students. Again, this result is consistent with the extant literature that predicts racial minority children to be more adversely affected by community traumatic events.

Importantly, the results presented in table 8 indicate that the October 2002 sniper attacks significantly harmed academic achievement in schools serving disadvantaged populations, and these effects were not driven by districtwide trends in performance. Rather, these effects represent negative deviations from trends and suggest that the findings documented throughout much of this paper—the 2002 Beltway Sniper attacks reduced academic achievement in Virginia's public schools—were largely driven by declines in student achievement in schools serving socioeconomically disadvantaged and racial-minority students. This is unsurprising, as these students, communities, and schools are regularly subjected to numerous other stressors and have relatively fewer resources with which to cope with unanticipated shocks (such as the sniper attacks), which presented yet another hurdle to overcome for students, teachers, and administrators in these schools.

## 7. DISCUSSION

The increased frequency of school shootings and community traumatic events in the United States places a large and rising number of children at an enormous risk for psychological problems. The current study documents that these types of events not only undermine the psychological well-being of children, but can also disrupt their cognitive development, especially in the short run. Difference-in-difference estimates that leverage the natural experiment created by the October 2002 Beltway Sniper attacks indicate that children who attended schools close to the shooting locations experienced lower academic achievement than their counterparts who attended schools farther away. The estimates are most robust for proficiency in third- and fifth-grade math, suggesting that shootings caused a decline in school proficiency rates of about 3 to 5 percentage points. Particularly concerning from an equity standpoint, these effects appear to be entirely driven by achievement declines in schools that enroll large numbers of racial minority and socioeconomically disadvantaged students.

The plausibility and practical significance of these results can be interpreted in a couple of ways. First, we put our findings into context by comparing them to those from several studies that consider similar sources of traumatic experiences or toxic stress. For example, Sharkey et al. (2014) use data from a sample of New York City public schools to explore the impact of exposure to community violence on children's test scores. Consistent with our results, they find that the impact of violence is most pronounced among African American students, who experience a 2.8 percentage point decrease in the likelihood of passing the ELA exam. This effect size is within the range (2.4–4 percentage points) obtained in our analysis. Similarly, Beland and Kim (2016)

**Table 9.** Schools whose Adequate Yearly Progress Proficiency Status Was Affected by Sniper Attacks

| | Treated Schools (Would Have Passed) | | | Control Schools (Would Have Failed) | | |
|---|---|---|---|---|---|---|
| | All Schools (1) | Top Tercile FRPL (2) | Top Tercile Black (3) | All Schools (4) | Top Tercile FRPL (5) | Top Tercile Black (6) |
| English 3 | 3 | – | – | 11 | – | – |
| Math 3 | 0 | 0 | 0 | 1 | 5 | 6 |
| English 5 | – | – | 0 | – | – | 2 |
| Math 5 | 4 | 5 | 3 | 18 | 15 | 17 |
| Total | 7 | 5 | 3 | 30 | 20 | 25 |
| Percent | 1.5% | 18.5% | 7.0% | 1.3% | 19.8% | 17.1% |

*Notes:* Based on baseline estimates from column 2 of table 4 and columns 2 and 4 and table 8. Numbers are only reported for tests on which there were statistically significant effects. FRPL: free or reduced-price lunch eligible.

find that deadly high school shootings reduce school proficiency rates in math and ELA by 4 to 5 percentage points.

Gershenson and Hayes (2018) show that the unrest experienced in Ferguson, Missouri, in 2014 in the aftermath of the police shooting of an unarmed black teenager led to 15 and 8 percentage point increases in the fraction of students who scored "below basic" in math and reading, respectively. The estimates obtained in that study are larger than those found here. However, unlike the sniper shootings, the civic unrest experienced in Ferguson affected already disadvantaged communities and caused a disruption over the course of the entire academic year. Our estimates also compare reasonably well with respect to studies that consider relatively milder shocks to learning environments. For example, Carrell and Hoekstra (2010) show that exposure to a peer from a household associated with domestic violence leads to a 1.6 percentage point reduction in the likelihood of college enrollment. Similarly, Marcotte and Hemelt (2008) estimate the impact of unscheduled school closings on school proficiency rates in Maryland by exploiting the natural experiment created by temporal and geographic variation in snowfall. The authors find that ten unscheduled, weather-related school closings reduced third- and fifth-grade math proficiency rates by between 5 and 7 percentage points. These effects are remarkably similar in magnitude to the effects of the sniper attacks documented in the current study.

Second, one dimension of the policy relevance of our findings can be inferred by considering how the sniper-induced reductions in proficiency rates affected schools' standing under the NCLB accountability policy, which was first implemented in the same school year that the sniper shootings occurred. Importantly, math and ELA proficiency rates determined whether schools made AYP under NCLB. To make AYP, among other things, schools' overall proficiency rates must meet or exceed a threshold predetermined by the state. In 2003 the ELA and math proficiency thresholds were 61 and 59, respectively (Virginia Board of Education 2010). Under NCLB, failing to make AYP in two consecutive years subjected schools to potentially severe sanctions.

Table 9 reports tabulations from a simple back-of-the envelope calculation of the number of schools whose proficiency rating would have crossed the AYP threshold had they (not) been within 5 miles of the sniper attacks. Specifically, we use the baseline estimates reported in tables 4 and 8 to compute two counterfactuals: the number of treated schools that failed but would have passed had they been outside the 5-mile radius of the nearest sniper shooting, and the number of control schools that passed but would have failed had they been inside a 5-mile radius of the nearest sniper shooting. Overall, the sniper shootings changed between 1 and 2 percent of schools' positions relative to the AYP threshold. However, this figure is significantly higher for schools in the top terciles of the distributions of the percentage of students eligible for FRPL and the percentage of black students. In these relatively disadvantaged schools, between 7 and 20 percent of elementary schools' positions relative to the AYP threshold changed as a result of the sniper attacks. This is consistent with results presented in table 8, which show that disadvantaged schools were particularly harmed by the sniper attacks, but is also driven by the fact that many disadvantaged schools were initially closer to the AYP thresholds due to their relatively lower proficiency rates. Accordingly, it is important that state and federal consequential K–12 accountability policies recognize the impacts that community traumatic events can have on the student test scores that determine sanctions, as failing to do so might expand existing inequities between schools.

More generally, these findings suggest that local and state education systems might respond to community traumatic events by providing additional resources, support, and guidance to affected schools and communities. For example, Weems et al. (2009) describe a school-based intervention that significantly reduced test anxiety among racial minority students who were exposed to Hurricane Katrina. Moreover, targeted support would be justified, given that disadvantaged schools and communities appear to bear a disproportionate burden of the harmful effects. There are also implications for proactive policies designed to eliminate or minimize the proclivity of manmade community traumatic events, as doing so in an efficient manner requires equating the marginal cost and marginal benefit of such efforts. The results presented here suggest that the costs of random shooting incidents may be larger than previously thought, as the psychic and emotional costs recognized by previous research spill over into schools and affect students' cognitive development and exam performance some five months after the event.

Finally, our auxiliary analysis suggests that the main deleterious impact of the sniper shootings on student achievement did not persist into the subsequent academic year, at least as measured by SOL proficiency rates. When we repeated our analysis with data extending to the end of the academic years 2004 and 2005, estimated treatment effects in these later years are smaller in magnitude and less precisely estimated than those in the academic year 2003. On the one hand, this finding can be interpreted as a glimpse of positive news because there might have been a correction to the disruption caused by the sniper attacks that brought achievement trends back to their pre-attack trajectories. However, this should not lessen concerns over the impact of community-wide traumatic events on student development for at least three reasons. First, any public and private efforts expended to counter the harmful effect of these attacks on student achievement would still represent an efficiency loss for society in light of the scarcity of educational resources. Second, educational interventions that affect both test scores and noncognitive skills often have long-run impacts on socioeconomic outcomes (e.g., labor market success) even when their effects on test scores fade out relatively quickly (Chetty et al. 2011). Finally, the dosage models reported in table 7 suggest that effects may have persisted in some of the most intensely treated schools.

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## APPENDIX A

**Table A.1.** Sensitivity of Baseline Estimates to Functional Form of Distance

| Subject | English 3 (1) | English 5 (2) | Math 3 (3) | Math 5 (4) |
|---|---|---|---|---|
| Panel A: Alternative Thresholds to Define Binary 'Closeness' Treatment (each cell is a unique regression) | | | | |
| 3 miles | −2.276 | −1.153 | −2.639 | −1.566 |
| | (1.375)* | (1.576) | (1.268)** | (1.784) |
| 4 miles | −2.744 | −0.885 | −2.736 | −1.118 |
| | (1.190)** | (1.351) | (1.100)** | (1.502) |
| 5 miles (Baseline) | −1.924 | −1.376 | −2.624 | −2.974 |
| | (1.087)* | (1.167) | (0.964)*** | (1.350)** |
| 6 miles | −1.381 | −0.227 | −2.552 | −2.426 |
| | (1.045) | (1.162) | (0.943)*** | (1.374)* |
| 7 miles | −1.567 | −0.882 | −2.196 | −1.652 |
| | (0.955) | (1.020) | (0.895)** | (1.257) |

**Table A.1.** Continued.

| Subject | English 3 (1) | English 5 (2) | Math 3 (3) | Math 5 (4) |
|---|---|---|---|---|
| Panel B: Continuous Quadratic Function of Distance to Attack | | | | |
| Miles | 0.178 | 0.207 | 0.325 | 0.264 |
| | (0.136) | (0.147) | (0.131)** | (0.187) |
| Miles$^2$ | −0.004 | −0.003 | −0.006 | −0.005 |
| | (0.003) | (0.003) | (0.003)** | (0.004) |
| APE | 0.067 | 0.115 | 0.142 | 0.116 |
| | (0.061) | (0.063)* | (0.056)** | (0.070) |
| Joint (*p*) | 0.40 | 0.16 | 0.04 | 0.30 |
| Panel C: Multiple Discrete Distance Categories | | | | |
| 0 to 5 miles | −1.934 | −1.819 | −2.800 | −2.770 |
| | (1.175) | (1.219) | (1.039)*** | (1.457)* |
| 5 to 10 miles | −0.027 | −1.166 | −0.465 | 0.540 |
| | (1.059) | (1.070) | (1.045) | (1.397) |
| Joint (*p*) | 0.21 | 0.26 | 0.02 | 0.08 |
| Difference (*p*) | 0.13 | 0.63 | 0.04 | 0.04 |
| *N* | 2,851 | 2,881 | 2,848 | 2,878 |

*Notes:* The omitted category in panel C is (>10 mi. from attack). Standard errors in parentheses are robust to clustering at the school level. Analytic samples restricted to schools within 50 miles of at least one sniper shooting. All models control for school and year fixed effects, district-specific linear time trends, and time-variant school controls including full-time equivalent teachers, student–teacher ratio, total school enrollment, percent black, percent Hispanic, and percent free or reduced-price lunch eligible. Sample contains data from 1998 to 2003 school years (6 years). Observations in 2002 for schools within 5 miles of the Pentagon are excluded from the analytic samples.

***Statistical significance at the 99 percent confidence level; **statistical significance at the 95 percent confidence level; *statistical significance at the 90 percent confidence level.