UNIVERSITY OF GOTHENBURG

SCHOOL OF BUSINESS, ECONOMICS AND LAW

Gun violence and school achievement: Evidence from Sweden

Ellinor Stensson

Supervisor: Ann-Sofie Isaksson
Master's thesis in Economics, 30 hec
Spring 2023
Graduate School, School of Business, Economics and Law, University of Gothenburg, Sweden

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This paper examines how educational outcomes in grade six are affected by gun violence that occurs in proximity to primary schools in Sweden. With geo-referenced data on gun violence over the period between 2018 and 2022, the thesis geographically matches spatial data on 1,811 shootings with national test results in mathematics and background data on 2,304 Swedish primary schools. To identify the impact of gun violence, the main analysis relies on temporal and spatial variation in the occurrence of shootings. The empirical results consistently indicate a negative relationship between exposure to gun violence and students' school outcomes. The negative relationship seems to be relatively short-term but could have negative consequences for students' future life outcomes.

Key words: Gun violence, Educational outcomes, Sweden

Contents

1 Introduction

In recent years, an increasing number of gun homicides arising from conflicts in the criminal milieu has become an important concern in Sweden. In 2022, the number of people shot dead in a year reached an all-time high, when 61 people were killed due to gun violence. According to the Swedish National Council for Crime Prevention (2021, p. 5), the level of gun homicide in Sweden now ranks "very high" compared to in other European countries, with approximately four deaths per million inhabitants per year. As a consequence of the higher number of gun homicides, shootings among criminal actors have become intensively debated and condemned in Sweden, with people asking for action and expressing fear, anger and worry about a gun violence incident happening to them or someone they are close to (see e.g., Kerpner, 2023; Mossige-Norheim, 2023; Romlid et al., 2019; Svennebäck, 2022).

The surge in the number of deadly shootings in Sweden has also been extensively covered in media, with a comprehensive number of newspaper articles, podcast episodes, radio shows, documentaries etc., produced (e.g., Faraj & Bergvall, 2021; Fernandez, 2017; Lindahl & Quintana Melin, 2021-present; Romin, 2021; Salihu, 2021; Sehlstedt, 2023). In this context, in November 2022, the Swedish public service television company, Sveriges Television (SVT), published data revealing that more than 700 of the shootings over the period from October 2019 to October 2022 had occurred less than 500 meters from a primary school in Sweden (Persson et al., 2022). A similar, yet not as noticed article had previously been published by Erlandsson et al. (2021) who showed that more than 40% of all shootings with victims between January 2017 and August 2021 had occurred less than 150 meters from a Swedish pre- or primary school. The information on how hundreds of shootings had occurred close to schools in Sweden became widely circulated and provoked reactions and discussion on how shootings close to schools might affect children (see e.g., Björnsdotter Grönkvist, 2022; Persson et al., 2022; Öhman, 2022).

Despite the attention towards shootings that occur in proximity to schools in Sweden, little is known about the consequences of such violence, which potentially goes beyond the casualties of the people involved in criminal activity and its victims. In particular, gun violence might have short-term as well as long-term welfare consequences if such violence affects the production of education, schooling and human capital accumulation. Previous studies that have found such negative consequences of gun violence have almost exclusively been conducted in Latin America (e.g., Michaelsen & Salardi, 2020; Monteiro & Rocha, 2017, see section 2.2), i.e., in countries that are different from the setting in Sweden with regards to institutions, socio-economic conditions, crime rates etc. Consequently, the results from previous studies might not necessarily be extrapolated to the Swedish setting, implying an important gap in research which this thesis aims to fill. More specifically, this thesis addresses the negative effects of gun violence that potentially goes beyond the criminal milieu in Sweden by examining the question of how gun violence that occurs near Swedish primary schools affects students' educational outcomes.

To study the relationship between gun violence and students' schooling performance, the identification strategy of this thesis relies on data on shootings with detailed geocoding information from the Swedish National Police. The access to fine-grained data makes it possible to link gun violence to specific schools and time periods more closely than in

previous studies. In addition, the data in this thesis does not only include information on homicides but also on non-fatal shootings with either wounded victims that have survived and/or shootings without persons hit. This makes it possible to examine whether the impact of gun violence is heterogeneous across person-hit and no-person-hit shootings, something that most earlier research has not been able to do.[1]

In Sweden, most gun violence takes place within the context of criminal conflicts (Council for Crime Prevention, 2021), and once a conflict has been triggered, anxiety and safety concerns tend to increase in the conflict's location. Against this background, a negative relationship between shootings in proximity to Swedish schools and students' educational outcomes may be expected. For example, a shooting that occurs close to a school may reduce students' willingness to attend their school, cause stress and anxiety, and disrupt students' study routines. Only a rigorous statistical analysis can validate or invalidate these predictions.

2 Gun violence and educational outcomes

2.1 Theoretical framework

The existing literature proposes various mechanisms through which gun violence may affect students' educational outcomes. Such mechanisms may in turn be classified into demand- and supply-side mechanisms (Michaelsen & Salardi, 2020). Supply-side mechanisms refer to possible drivers of deterioration in the quality and access to education. Violence may lead to demolition of school buildings or related infrastructure or result in disruption of school activities. For instance, Monteiro and Rocha (2015) show that schools in violent areas in Mexico experience less stability in the school administration and more temporary school closures. Violence might also affect the quality of the learning environment negatively by increasing teacher turnover and/or teacher absenteeism. Teacher absences may in turn reduce students' academic achievements by creating discontinuities of instruction and decreasing instructional intensity (see Miller et al., 2008).

Demand-side mechanisms focus on how students' educational performance is affected by violence. Most demand-related research has concentrated on the possibility that violence might lead to increased student absenteeism, out-migration, or withdrawal from school (Michaelsen & Salardi, 2020). More recently, also the roles of acute and prolonged psychological stress have been proposed as demand-side mechanisms. Specifically, psychologists and sociologists have linked exposure to community violence to consequences such as anxiety, depression, hypervigilance and impairments in cognitive performance (e.g., Gorman–Smith & Tolan, 1998; Fowler et al., 2009). Violence can also affect school attendance. When a shooting occurs near a school, parents might feel unease about having their children attending the school. Low school attendance may in turn have negative consequences for learning outcomes if students miss out on curriculum content and day-to-day contact with teachers and other students. Exposure to local gun homicides can also reveal information about likely victimization to both students and parents (Koppensteiner & Menezes, 2021). To the extent that such information affects students' perceived expected lifetime, exposure to gun

[1] As far as the author of this thesis is aware of, only Monteiro and Rocha (2017) have previously managed to explore the impact of no-person-hit gun violence. Their data on shootings was however not provided by an official authority but rather from a crime hot line.

homicides might have an impact on the expected returns to education and thus the optimal schooling decision.[2]

In the Swedish context, due to the nature of the violence and the conflicts in the criminal milieu, shootings are generally not accompanied by destruction of infrastructure that is essential for supplying education (e.g., school buildings, public transportation services, roads). Hence, this thesis will mainly focus on the short-term demand-side mechanisms, which seem to be of more relevance for gun violence that takes place in a non-war-torn setting. Specifically, mechanisms such as psychological stress and lower schooling attendance can be assumed to be of higher importance for explaining any eventual impact of gun violence in the Swedish setting, compared to mechanisms related to the supply of education.

While the main analysis of this thesis focuses on a relatively short-term impact of gun violence, it is possible that there are also more long-term mechanisms through which gun violence might affect students' educational outcomes. On the demand side, parents might respond to gun violence by moving to a different neighborhood or transferring their children to a school in a different area, something that is possible due to the free school choice in Sweden (see section 3.2). Furthermore, on the supply-side, teachers might choose to leave schools that are exposed to gun violence for schools that are located in areas where the probability of shooting incidents is lower. These effects are less likely to be observed in the short run as school transferring does not usually occur in the middle of a term, but rather between school years. Furthermore, even if parents and teachers decide to move away from a certain neighborhood and school after gun violence has occurred near a school, this will most likely occur with a time lag because of the time it takes to find a new home or job and transit.

2.2 Previous literature and contribution

This paper broadly relates to the literature on the educational consequences of violence (for an overview, see e.g., Blattman & Miguel, 2010; Justino, 2012). The empirical evidence in this literature suggests that small shocks that reduces access to education can have long-lasting detrimental impacts on human capital accumulation, health outcomes and labor market opportunities (e.g., Ichino & Winter-Ember, 2004; Akbulut-Yuksel, 2014). The existing research also implies that the impact of violent conflict on education is heterogeneous, with the magnitude and sign depending on factors such as the characteristics and geographical location of the conflict, the educational outcome that is studied, and students' age, ability and gender (e.g., Chamarbagwala & Morán, 2011; Shemyakina, 2011; De Groot & Göksel, 2011; Justino, 2012; Valente, 2014; Swee, 2015; Guariso & Verpoorten, 2019; Verwimp et al., 2019). For example, Shemyakina (2011) finds girls to suffer the greatest loss in educational attainment from exposure to violence in Tajikistan, possibly due to lower returns to girls' education and concerns over safety. Akresh and de Walque (2008) in contrast find boys in non-poor households in Rwanda to suffer the largest consequences of negative shocks to education, potentially because they are disproportionally affected from an overall reduction in schooling outcomes due to their previously advantaged educational position.

[2] For a detailed description on the relationship between expected lifetime and the optimal schooling decision, see e.g., Carbone and Kverndokk (2017).

Within the research on the educational consequences of violence, the strand of literature that is most closely related to this paper is that which explores the relationship between gun homicides and educational outcomes. Most of this literature focuses on the context of Latin America. In Colombia, Fergusson et al. (2020) use data from "La Violencia", a period characterized by intense political violence between 1948-1953, to examine how violence affects educational attainment. The authors present evidence that individuals who belong to a cohort that was exposed to violence during, and especially before, their education years experience a significant reduction in years of schooling. Monteiro and Rocha (2017) examine how gunfights among drug gangs in Rio de Janeiro's favelas (slums) affect students' test scores on a national standardized exam taken by fifth graders and find that students' math scores are lower in years in which they are exposed to drug battles. The effect also appears to increase with conflict duration, proximity to exam dates and conflict intensity. Similar results are obtained by Michaelsen and Salardi (2020) who document violence related to the "war on drugs" in Mexico between 2006-2011 to have a negative impact on educational performance. Again, the impact appears to increase with geographic proximity and levels of violence. The authors also find evidence that the short-term impact of drug-related homicide substantially exceeds the long-term effect spread over a full school year.

Koppensteiner and Menezes (2021) use a broader measure of violence, including both drug and non-drug related homicides, to examine how exposure to homicides around schools, students' residence, and on students' way to school affects schooling performance in São Paulo. The empirical evidence from the study implies a negative impact on standardized test scores from violence. Exposure to violence is also found to increase dropout rates of students significantly and to have a detrimental effect on school attendance in São Paulo. In a similar study from Mexico, Brown and Velásquez (2015) exploit temporal variation in violence induced by drug conflicts to examine how increases in drug-related violence affects educational outcomes and employment behavior of young adults. They find escalation of drug-related crime to be negatively associated with the likelihood of completing compulsory schooling. Specifically, individuals who are exposed to an increase in the level of drug-related crime are found to be about eight percentage points less likely to graduate from ninth grade. The authors also present evidence that exposure to an increase in violence is associated with a reduction in years of education attained by approximately 0.3 years among young males.

Studies on the association between violence and students' educational outcomes conducted outside of the Latin American context are substantially scarcer. One exception is Brück et al. (2019) who exploit variation in the number of Palestinian fatalities in the Israeli-Palestinian conflict to examine the impact on educational outcomes for high school students in Palestine. The authors find conflict to reduce the probability of passing the final exam, the test score results, and the probability of being admitted to university. Lastly, two recent (yet unpublished) studies from the United States examine how educational outcomes are affected from school shootings, where students themselves are the intended victims, and find various educational outcomes to deteriorate after a shooting has occurred (see Cabral et al., 2021; Deb & Gangeram, 2021).

This paper aims to contribute to the existing body of evidence in three ways. First, this thesis is pioneering in that it studies gun violence and its impact on school performance in a Western high-income country context. As the previous literature review reveals, the earlier

research on the relationship between educational outcomes and gun shootings has – as far as the author of this thesis is aware – exclusively been conducted in countries that are different from the countries in the Western world with regards to institutions, socio-economic conditions, crime rates and so on. Consequently, little is known on whether the results from previous studies can be extrapolated to the high-income countries in the West, implying an important gap in research which this thesis aims to fill.

Second, this thesis uses a novel dataset with precise geocodes on gun violence from the Swedish National Police, which makes it possible to link gun shootings to specific schools and time periods at a greater level of detail than in previous studies. Due to the detailed data from the police, this thesis is also able to include shootings without persons hit in the analysis, meaning that both shootings with and without victims (persons hit) are captured. This makes it possible to examine if the impact of shootings on schooling outcomes is different across person-hit and no-person-hit shootings, something that earlier research has not been able to do.

Third, due to the rich information on school characteristics and outcomes in the dataset that this thesis uses, it is possible to investigate whether the effect of gun violence is different across different outcomes (total average test score and share passing the national tests) and genders. Previous research has documented that exposure to conflict can lead to significant gender differentials in educational outcomes (see e.g., Akresh & de Walque, 2008; Shemyakina, 2011). Furthermore, girls and boys might experience differential effects of exposure to gun violence because of gender differences in the probability of gun victimization as well as perpetration in Sweden (see section 3.1). As the actors who engage in gang violence are typically young males, it is likely that boys' expected returns to education and opportunity cost of attending school is more impacted from exposure to gun violence than girls'. To explore this prediction, section 6.3 of this thesis examines gender differences in the relationship between exposure to gun violence and students' educational outcomes.

3 Background

3.1 Gun violence in Sweden

Over the period between 1960 and 1990, most Western European countries experienced an increasing trend in the number of (gun) homicides, which has since then declined. In Sweden however, this downward trend has stalled, and since 2013 the level of homicide has again started to increase. Today, the rate of homicides in Sweden is higher compared to in many other European countries, which can primarily be attributed to an increase in the level of gun homicides since 2005 (National Council for Crime Prevention, 2021). Before 2013 this increase was compensated by the decreasing trend in the number of homicides by other means, but since then, the higher number of gun homicides has caused the total homicide level in Sweden to rise. Most of the increase has occurred within the context of criminal conflicts, and gun homicides outside the criminal milieu are relatively rare. Currently, the rate of gun homicides in Sweden is approximately four per million habitants, which is high in relation to the European average of 1.6 gun homicides per million people (Government Offices of Sweden, 2022; Mondani & Rostami, 2023).

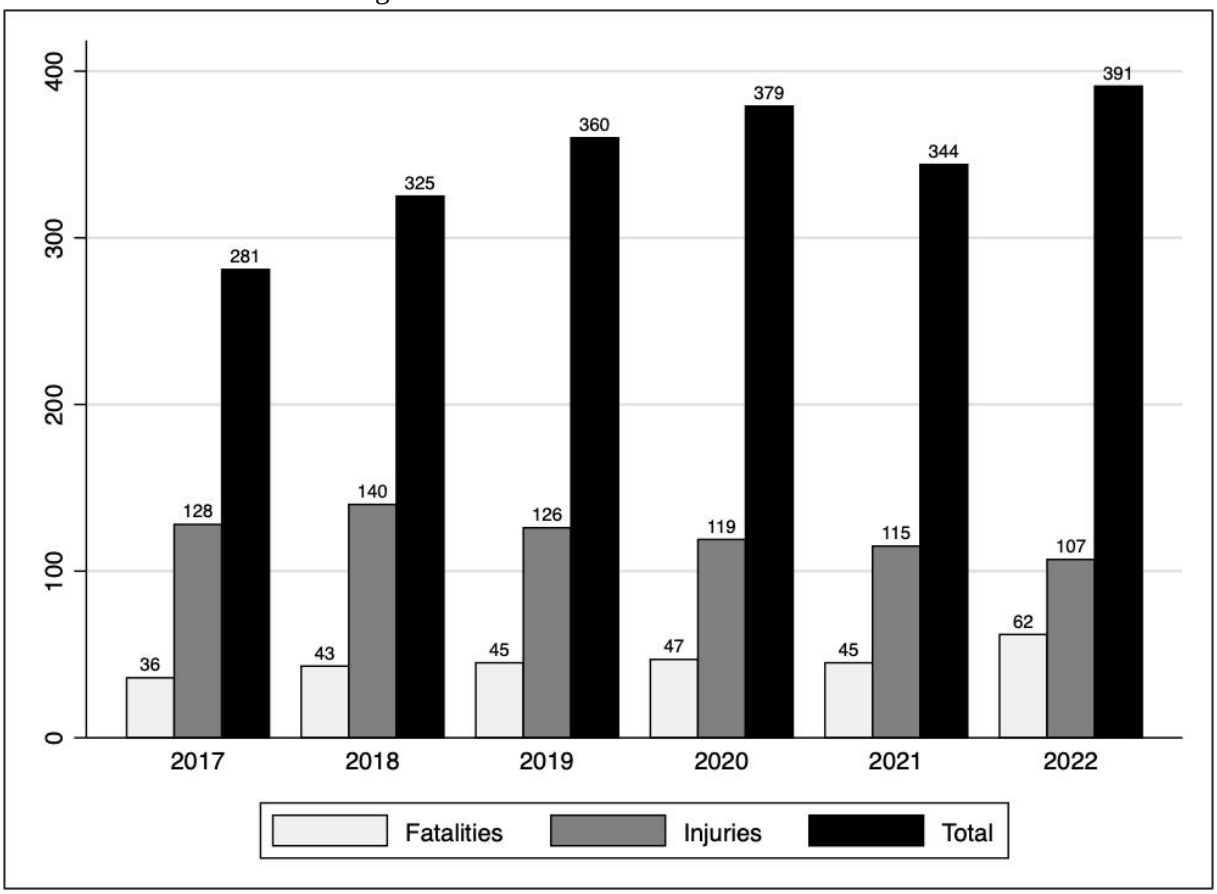
The gun violence is not evenly distributed throughout Sweden, neither geographically nor in the population. As reported by the National Council for Crime Prevention (2021), the

gun violence in Sweden occurs more frequently in the major metropolitan areas, where a majority of the criminal conflicts take place. Even within the metropolitan areas, shootings tend to take place more often in socially disadvantaged neighborhoods, which are classified by the Swedish Police Authority as "vulnerable"[3] (National Council for Crime Prevention, 2020). Furthermore, the individuals who are involved in the gun homicides in Sweden are almost exclusively men. In 2022, 98 percent of the fatal shooting victims were male (National Council for Crime Prevention, 2023). The victims as well as the perpetrators of fatal and non-fatal gun violence also tend to be relatively young. Accordingly, the increased gun violence in Sweden since 2005 has to a large extent been concentrated to men between 15 and 29 years (National Council for Crime Prevention, 2019).

Following the surge in the numbers of gun homicides in Sweden, the Swedish National Police was instructed by the government to keep statistics over the number of shootings in November 2016. Figure 1 shows the total occurrence of shootings with the number of people who were killed and wounded for the full years when data is available. As Figure 1 reveals, the total number of shootings with or without victims has exceeded 300 per year in all years between 2018 and 2022. The total number of shootings has also increased in all years but 2021, potentially due to the COVID-19 pandemic. Figure 1 also reveals a growing trend in the number of fatal shootings, while the occurrence of injuries has declined slightly over the period. This is in line with the Swedish National Police's (2023) observation that criminal actors in Sweden have increasingly been shooting with the purpose to kill, rather than to scare and/or wound their victims. Over the period 2017-2022, the average number of shootings in a year is 347, with roughly 46 people killed and 123 people wounded. In 2022, the number of shootings reached 391, which is the highest number observed over the period between 2017-2022. Furthermore, during the same year, the number of people who were killed in gun violence amounted to 62, implying that 17 more fatal shootings occurred in 2022 compared to the year before.

[3] Vulnerable areas are areas that are considered to be vulnerable on the basis of various criteria linked to the area's socio-economic situation (e.g., high unemployment, ethnic segregation and low incomes), and where criminal actors have an influence on the local society (Swedish National Police, 2015).

FIGURE 1. Confirmed shootings in Sweden between 2017 and 2022.



Notes: The bars *fatalities* and *injuries* indicate the number of people who were killed and wounded in gun violence during each year, respectively. The bar *total* shows the number of shootings with and without persons hit. The diagram has been created by the author of this thesis with statistics from the Swedish National Police. (n.d.).

3.2 Education in Sweden

The education system in Sweden is governed by the state through a number of statutes, government orders, syllabuses and curricula. The National Education Agency (Skolverket), the central administrative authority for the public school system, is responsible for evaluating, developing and supervising the education. Each municipality provides primary, upper secondary and municipal adult education. The education is normally financed from public means and exempt from fees (National Education Agency, 2019).

Since the school year 2018-2019[4] the Swedish School Act mandates all children in Sweden to go to school for at least 10 years from the year they turn six. The compulsory schooling starts with a preschool year (year 0) and is followed by the junior level of compulsory school (year 1-3), the intermediate level of compulsory school (year 4-6) and the senior level of compulsory school (year 7-9). Since 2016, grades are assigned to students from year six. The grading scale includes grades from A to F, where A-E are passing grades and F is a failing grade. Most of the schools in Sweden are public municipal schools, but the education system also includes an increasing number of independent schools with public funding. In the school

[4] Before the school year 2018-2019, attending a preschool year was not mandatory.

year 2021–2022, 16 percent of all compulsory school students in Sweden attended an independent school (National Education Agency, 2022a). Students in Sweden have the right to choose which particular school they wish to attend, no matter whether the school is located in their catchment area or not. In practice, this ability to choose school – the free school choice – is to a larger extent utilized by students with parents of high socioeconomic status and has therefore been criticized for contributing to socioeconomic segregation in the education system in Sweden (Brandén & Bygren, 2022; Böhlmark et al., 2015; National Agency for Education, 2003).

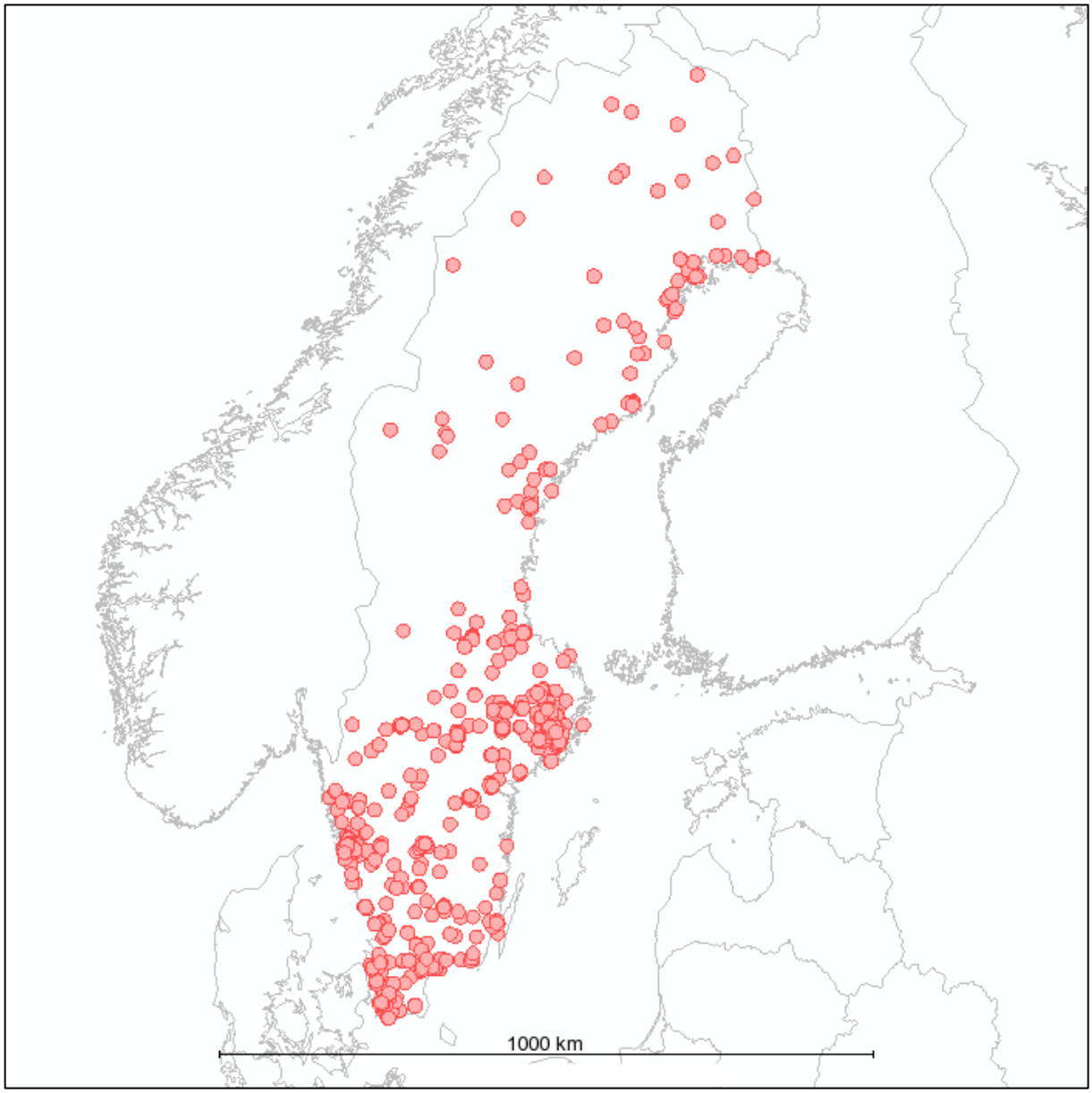
3.2.1 National tests

In Sweden, all students in compulsory school year three, six and nine must complete national tests in certain subjects every year. The purpose of performing the tests is to support teachers in assessing and grading the students' knowledge in accordance with the educational requirements to ensure equal and fair assessment of students' knowledge (National Education Agency, n.d.-a). The tests are developed and constructed at various Swedish universities on behalf of the National Education Agency with tasks that have been tested at multiple schools in different parts of Sweden. All tests include oral, writing and reading exercises.

In grade three, the tests are performed in mathematics and Swedish or Swedish as a second language. As opposed to in year six and nine, the tests are not graded, but rather serve as an assessment of the student's general knowledge. The national tests in year six comprise mathematics, Swedish or Swedish as a second language and English. In year nine, the national tests cover the same subjects as in year six, but also include one of the subjects physics, biology or chemistry as well as one of the subjects geography, religion, history or social sciences (National Education Agency, 2023).

The national tests in year six, which this thesis uses the results from, are comprised of oral, writing and reading parts in all subjects. The oral parts are normally performed over a period of five weeks during the autumn term and schools are able to decide the exact dates when the verbal tests should be completed themselves. This contrasts the written parts, which all students in Sweden have to perform at specific dates set by the National Education Agency during the spring term. The national tests in mathematics include one verbal test that students perform in groups of three to four students and four written parts that students solve individually. In English, the national tests consist of four parts. One part is oral, while the other three assess knowledge within the areas of reading, reception/listening, and writing. Finally, the national tests in Swedish and Swedish as a second language are common tests in five parts. One part is verbal, two parts measure reading comprehension and the last two parts comprise tasks that assess students' writing ability. The different parts in mathematics, English and Swedish (Swedish as a second language) are weighted together into one final grade in each subject (National Education Agency, 2023).

FIGURE 2. The locations of all shootings in Sweden between 2018 and 2022.



Notes: The figure has been constructed with GPS Visualizer and data on shootings' location from the Swedish National Police.

4 Data

4.1 Data on gun violence

To understand the consequences of gun violence in proximity to primary schools in Sweden, detailed information on when and where shootings have taken place is required. A *shooting* is defined by the Swedish National Police (n.d.) as an occasion when projectiles have been fired from a weapon loaded with gunpowder, and where there exists either a) traces in the form of bullets, cartridge cases or damage to material or humans, or b) at least two independent eyewitnesses to the shooting. The discharge of the weapon must also be non-legal and not clearly unintentional (Swedish National Police, n.d.). Information on all shootings that fall under this definition is publicly available from the National Police Authority on request.

The dataset from the National Police Authority covers all shootings, with or without injured victims, that occurred in Sweden between 2018 and 2022 and includes information on the dates of shootings, the number of people killed, the number of people injured and the approximate GPS coordinates for the shootings' locations. The data is collected from the seven police regions in Sweden twice every month.[5] In total, 1,811 shootings are covered in the dataset. Information on the exact date of the shooting is available for all shootings, and GPS coordinates are available for 1,705 of them. Having access to such fine-grain information on shootings is uncommon in the literature on gun violence and school outcomes and offers a unique opportunity to link gun shootings to specific schools and time periods more precisely than in previous studies.

In the raw data from the National Police Authority, the GPS coordinates for 65 shootings are not correctly reported[6], and for another 39 shootings, the GPS coordinates have not been entered at all. Not taking this into account could lead to omitted variable bias if the probability of inaccurate or missing coordinates varies across shootings due to some unobserved component. To solve this issue, the coordinates for these shootings are approximated from the news media's reporting on the shootings and from the compilation of shootings by Hedström et al. (2022). This is possible for 102 out of the 104 shootings. To make sure that the manual imputation of approximate coordinates does not drive the results in the analysis of this thesis, a dummy is created to control for the manually imputed shootings and run the main regressions with and without them (see Appendix A). Figure 2 shows where the 1,809 shootings for which GPS coordinates are available have occurred.

4.2 Data on educational outcomes

The analysis of the impact of exposure to gun violence on educational performance in this thesis focuses on the school years from 2016-2017 to 2021-2022[7], and uses data from the National Agency for Education (n.d.-b, n.d.-c). The information is provided at the school unit level and includes statistics on the number of students, final grades, national test results and demographic data on the school's population. Data on the number of students, final grades, and demographic data is available for all years that this thesis examines, i.e., from the school year 2016-2017 and onwards. The national test results for students in grade six are available for all school years but 2019-2020 and 2020-2021 (see below). To be able to compare a school's results over time, i.e., before and after a shooting has occurred, there must exist data for a certain amount of time before the shooting. Therefore, primary schools for which data is missing for more than one school year are not included in the final dataset. Ultimately, the sample for the main regressions in this thesis consists of 9,032 observations across 2,304 school units.

Table 1 below presents some descriptive statistics for the main variables that are used in this paper. As is shown there, the average total mathematics test score for the period of study is 12.11 and approximately 92% of the students have passed the mathematics exams, with

[5] More specifically, the police regions report statistics the 1st and the 15th, or the first weekday after, every month.
[6] The coordinates are reported in SWEREF 99 TM and some coordinates miss a digit, have too many digits or have been assigned with coordinates for places outside of Sweden.
[7] The results from the national tests in mathematics for the school year 2022-2023 are not available until the 1st of December, 2023 (National Education Agency, 2022b).

relatively little variation across the different school years. The average share of students with foreign background and the share of students that have parents with higher education are 26.85% and 57.74% respectively, and both shares are increasing in all school years over the period. Female students are in minority (48.79%) and the average number of students registered in grade six per school unit is approximately 42. Finally, the share of school units that has been exposed to a shooting during the five weeks before the first written national test in mathematics is taken is either 2% or 3% in all three school years when data is available.

The main outcome variables of the study are student scores on the sixth-grade national mathematics test and the share students passing the national tests in mathematics in a Swedish school in a given year. The data is provided by the National Education Agency (n.d.-b) and can be accessed through their statistics data base. Using data from the mathematics tests rather than the English or Swedish (Swedish as a second language) tests for the main analysis is motivated for multiple reasons. First, test scores in mathematics have previously been found to be more sensitive to conditions in the learning environment (e.g., Miller et al., 2008; Hanushek & Rivkin, 2010; Monteiro & Rocha, 2017; Gershenson & Tekin, 2018), implying that if there is a negative impact of gun violence on educational outcomes, the effect might be most detrimental to students' performance on the mathematics tests.

Second, as opposed to test scores in English or Swedish (Swedish as a second language), mathematics test scores have previously been used to study the impact of gun violence on academic outcomes in other settings (see Monteiro & Rocha, 2017; Brück et al., 2019; Michaelsen & Salardi, 2020; Koppensteiner & Menses, 2021), which means that using mathematics test scores will enable comparison of the results obtained in this study to previous findings.

Lastly, grading in mathematics tends to be more objective in the sense that a greater weight is accorded to actual academic performance compared to language, which is to a greater extent graded based on students' effort (class behavior, homework preparation and so on; Resh, 2009; Sabbagh et al., 2009; Prøitz, 2013). Thus, for the purpose of this thesis, the mathematics test scores seem to measure students' actual performance on the national tests most accurately.

As described in section 3.2.1, the national tests in Sweden are made up of different sub-tests (reading, writing, speaking and comprehending). Therefore, the test score that is used as outcome variable in the main analysis of this thesis is an average of the student's letter grades in all subtests in each subject converted into numerical scores. The average mathematics test scores are readily available in the dataset provided by the National Education Agency (n.d.-b) from four different school years between the school years 2016-2017 and 2021-2022. As previously mentioned, data is missing for the school years 2019-2020 and 2020-2021, when most of the national tests for compulsory school students were cancelled due to the COVID-19 pandemic. The dataset from the National Education Agency (n.d.-b) also includes information on the share of students that passes the national tests in each school year, which is used as an alternative outcome variable in the main analysis (see section 6).

TABLE 1. Descriptive statistics: Main variables.

	Mean	SD	Min	Max
2016-2017				
Total mathematics test score	12.06	2.17	3.3	17.9
Share passing the mathematics exams	92.74	11.64	40.8	100
Share with foreign background	25.68	21.12	3	98
Share with higher education background	55.99	16.91	13	95
Share of female students	48.63	4.78	17	79
Number of students in 6th grade	40.91	26.91	7	195
2017-2018				
Total mathematics test score	12.20	2.28	3.9	18.1
Share passing the mathematics exams	92.91	11.56	37.5	100
Share with foreign background	26.44	21.37	3	99
Share with higher education background	57.0	16.76	13	96
Share of female students	48.83	4.63	19	79
Number of students in 6th grade	40.49	26.84	1	221
Share of schools with shooting just before the tests	0.02	0.14	0	1
2018-2019				
Total mathematics test score	12.05	2.39	2.9	18.2
Share passing the mathematics exams	91.20	12.60	38.5	100
Share with foreign background	27.08	21.77	3	100
Share with higher education background	57.84	16.81	13	96
Share of female students	48.83	4.57	22	81
Number of students in 6th grade	42.09	27.08	1	222
Share of schools with shooting just before the tests	0.03	0.18	0	1
2021-2022				
Total mathematics test score	12.13	2.17	1.3	18.2
Share passing the mathematics exams	92.63	11.21	39.5	100
Share with foreign background	28.07	22.13	3	97
Share with higher education background	59.97	16.92	12	97
Share of female students	48.86	4.45	32	84
Number of students in 6th grade	43.15	26.87	1	224
Share of schools with shooting just before the tests	0.03	0.17	0	1
Total				
Total mathematics test score	12.11	2.26	1.3	18.2
Share passing the mathematics exams	92.36	11.79	37.5	100
Share with foreign background	26.85	21.63	3	100
Share with higher education background	57.74	16.91	12	97
Share of female students	48.79	4.61	17	84
Number of students in 6th grade	41.67	26.94	1	224
Share of schools with shooting just before the tests[8]	0.02	0.14	0	1
N	9,032			

4.3 Additional data

To determine the distance from shootings to primary schools, detailed information on the location of primary schools in Sweden is required. Due to the EU directive INSPIRE, all EU

[8] The school year 2016-2017 is not included as no data on the number of shootings is available.

Member States are required to share spatial data on a number of data themes, including the location of school units. Therefore, data on the exact location of primary schools in Sweden can be accessed from the National Agency for Education on request. The data includes information on the exact location of all primary schools that exists in Sweden in the school year 2022/2023, with exact GPS coordinates available for all school units but 54.[9] Thus, in the final dataset, the GPS coordinates for 54 primary schools are geocoded manually by converting schools' addresses into geographical coordinates with Google Maps.

As will be described in the consecutive section, the benchmark specification of this thesis uses school fixed effects to compare test results within school units over time. Solely relying on school fixed effects might however not be sufficient to estimate the causal relationship between gun violence and educational outcomes due to the possibility that also the student composition can change over time. To investigate if this is the case, and to be able to examine potential mechanisms underlying the results, multiple control variables are included in various alternative specifications in the sections that follow. More specifically, this thesis uses controls for the share of students that have parents with higher education, the share of foreign-born students, the share of female students and the total number of students in grade six at each school. The additional data on school characteristics are obtained from the National Education Agency (n.d.-c). The data is available for all schools in all school years that are studied in this thesis.

5 Identification strategy

5.1 Empirical strategy and econometric model

Identifying the causal impact of gun violence on educational outcomes is not straightforward due to various empirical challenges. First, gun violence is often linked to conflicts in the criminal milieu, which tend to occur more frequently in socially disadvantaged neighborhoods in the metropolitan areas of Sweden (National Council of Crime Prevention, 2021). Such conflict-affected neighborhoods are different from non-conflict ones in terms of individual and community characteristics that are hard to measure, implying that cross-section analysis that tries to identify the causal impact of gun violence is likely to be confounded by omitted variables. A related concern is that shootings tend to be correlated with factors such as a higher level of conflict among criminal actors in the neighborhood or increased activity in local drug markets, which could introduce bias to the analysis.

To circumvent these problems as far as possible, this thesis uses panel data and school fixed effects to account for average differences in shootings and educational outcomes across school units. This makes it possible to exploit the variation in gun violence in proximity to schools over time to investigate the relationship between gun violence and school results. The strategy with school fixed effects does however not manage to account for factors that are correlated with shootings such as the level of conflict among local criminal actors or changes in activity in neighborhood drug markets. Although students in sixth grade are probably less

[9] The reason why GPS coordinates are missing for 54 schools is that the coding that obtains GPS coordinates has not managed to extract any from the school's registered address.

affected by such factors compared to their counterparts in higher grades[10], this is a potential caveat that should be kept in mind when examining the findings of this paper.

A second threat to identification is that of reverse causality, that is, students' educational attainment might be a determinant of the number of shootings that occur in areas, so that areas with worse educational outcomes are characterized by a higher level of gun violence. While an increase in gun violence is likely to have a negative impact on students' school performance, poor educational performance could also contribute to gun violence as it might be easier for criminal networks to recruit individuals from poor-performing schools. If that is the case, the estimated coefficient for the gun violence-indicator will be biased upwards to the extent that the error term captures the effect of low-performing students engaging in gun-related violence. As previously described, this is why this thesis focuses on children in grade six (which students normally start in the year they turn 12 years), who are far less likely to be targeted for recruitment and involvement in gun homicides. Additionally, as this thesis uses variation within school units to examine the relationship between gun violence that occurs just before the national tests and students' educational outcomes, the risk for reverse causality should be small.

Finally, there may be a risk of measurement error with regards to both the educational outcomes and the location of gun violence. Grading is inherently a subjective process, where factors such as interpersonal liking, group stereotypes, and physical attractiveness may influence the grade assigned to a student (e.g., Van Ewijk, 2011). The results from nationally provided tests are however likely to be more objective than leaving grades because national tests are assessed with the help of standardized templates. The standardized templates provide teachers with detailed assessment instructions with assessment factors and authentic examples of different levels of student achievement with comments (National Education Agency, 2023). Thus, the risk of measurement error with regards to educational outcomes should be relatively small.

As regards the data on the location of gun violence in Sweden, there is a risk of measurement error in so far as the GPS coordinates for the shootings provided by the National Swedish Police are not exact. However, due to the confidentially of such information, it is not possible to obtain completely precise coordinates for the purpose of this thesis. In practice however, the difference between the actual GPS coordinates and the GPS coordinates provided by the National Swedish Police should be relatively small (i.e., some ten meters at maximum). Furthermore, as described in section 4.2 above, roughly 100 of the shootings in the sample are approximated from the news media's reporting and from the compilation of shootings by Hedström et al. (2022), as the coordinates are either inaccurate or missing in the dataset from the National Swedish Police. Whether the manual approximation of coordinates affects the results of the study is tested in Appendix A.2, where the regressions in the main analysis are re-run without the shootings that have inaccurate or missing coordinates.

[10] Students in grade six are both less likely to be targeted for involvement in gun homicides, and less likely to have started using drugs, compared to their older counterparts (see e.g., National Council for Crime Prevention, 2021; Swedish Council for Information on Alcohol and Other Drugs, 2022).

5.2 Econometric specification

This paper estimates the causal impact of gun violence on educational performance – measured by the national test score in mathematics (share passing the national tests in mathematics) as follows:

$$(1)\ y_{st} = \beta_0 + \beta_1 \tau_{st} + \beta_2 \mathbf{Z}'_{st} + \mu_s + \gamma_t + \varepsilon_{st},$$

where the dependent variable, $y_{st,}$ is the mathematics national test result (share passing the mathematics national tests) at school s in school year $t \in \{2016/17, 2017/18, 2018/19, 2021/22\}$, and where τ_{st} is the variable of interest; a dummy that indicates whether school s is affected by a nearby shooting before the national test in school year t. More specifically, this variable is defined in line with Monteiro and Rocha (2017) as

$$(2)\ \tau_{st} = 1 \text{ if } \sum_j \mathbb{1}\{D_{sj} < M\}\, \alpha_{jt} > 0, \text{ and 0 otherwise,}$$

where α_{jt} is the number of shootings that a given school experiences throughout a specified time period in school year t. In the benchmark specification, this period includes the five weeks (35 days) before the date in which the first written national test in mathematics is taken.[11]

The function $\mathbb{1}\{D_{sj} < M\}$ indicates whether the linear distance D_{sj} between school s and shooting j is less than M meters. In the benchmark specification, M is set to one kilometer, at which τ_{st} captures only shootings that occur up to 1,000 meters from the school. Thus, at benchmark, τ_{st} indicates whether school s experienced at least one shooting within $M = 1{,}000$ meters of distance during the five-week period before the first written national test in mathematics.

In equation (2), the choice of M can be viewed as a trade-off between precision on the one hand, and the size of the group of exposed school units on the other. If M is set to a distance shorter than 1,000 meters, a more precise exposure measure will be obtained compared to the baseline. This will however come at the cost of using only a smaller fraction of the 1,811 shootings over the period. If M is instead set equal to a distance larger than 1,000 meters, more shootings will be captured at the cost of less precision, i.e., more variation that is unrelated to exposure to gun violence will be included in the analysis. To examine whether using 1,000 meters as the measure of exposure in this thesis affects the results in the main analysis, the radius is varied by 10% in both directions to create alternative exposure measures of 900 meters and 1,100 meters around schools as a robustness check in section 6.2. Varying the radius also allows this paper to assess whether gun violence that occurs closer to primary schools has a larger impact on students' educational outcomes. The beforehand expectation is that gun violence that occurs further away from schools should have less impact on students' test results.

Similar to the choice of M, also the choice of time period in equation (2) comes with a trade-off between precision and the number of shootings that can be exploited in the analysis. While using a time period that is longer than the baseline (five weeks) means that more gun

[11] As the choice of exposure period is inevitably an arbitrary one, section 6.2 of this thesis investigates how using alternative exposure periods affects the results obtained from the benchmark specification.

violence can be used to estimate the relationship between gun violence and educational outcomes, a longer period will reduce the precision of the estimates. Considering a shorter time period in the analysis will instead create a more precise exposure measure, but only at the cost of reducing the number of shootings that can be exploited in the analysis. Since the choice of time period is inevitably a somewhat arbitrary one, the benchmark time period that is used in the main analysis is varied to investigate if the choice of time period affects the results in section 6.2.

In equation (1), $\mathbf{Z}'_{st}$ is a vector of time-variant school characteristics, namely the share of students with foreign background, the share of students with a higher education background, the share of female students and the number of students in grade six, which are included in the specification to absorb within-school heterogeneity. γ_t are year dummies that represent trends that are common for all schools in the sample, e.g., macroeconomic trends, national educational policies, and overall trends in criminal activity. The year fixed effects also pick up the impact of the COVID-19 pandemic that is common to all schools in the sample. The term μ_s represents school fixed effects which capture unobserved heterogeneity across school units regarding factors such as the number of parallel classes, teacher quality and classroom features. All regressions are estimated with standard errors clustered at the municipality level.

Specification (1) is a relatively demanding specification as it includes both time and school fixed effects. Including school unit-effects allows this thesis to control for school unit factors that are time-invariant, which – as described in the previous section – is motivated because gun violence tends to occur more frequently in socially disadvantaged neighborhoods that are different from non-disadvantaged neighborhoods. Disadvantaged neighborhoods are often characterized by higher unemployment, ethnic segregation, low levels of income and cramped housing conditions (see e.g., National Operations Department, 2015), which potentially has a negative impact on students' school results. The school fixed effects will pick up the effects of average differences in characteristics that are time-invariant within a school unit.

The main disadvantage of using school fixed effects in the regression is that no between-school variation can be exploited in the analysis. Such variation might however be important to identify the relationship between gun violence and educational outcomes. To examine this possibility, the following, less demanding model without school fixed effects is also estimated in a subsection of the main analysis:

$$(3)\quad y_{st} = \beta_0 + \beta_1\psi_s + \beta_2\tau_{st} + \beta_3\mathbf{Z}'_{st} + \theta_m + \gamma_t + \varepsilon_{st},$$

where the dependent variable, $y_{st,}$ is the mathematics national test result (share passing the mathematics national tests) at school s in school year $t \in \{2016/17, 2017/18, 2018/19, 2021/22\}$ as before. τ_{st} is a dummy that indicates whether school s is affected by a nearby shooting during the five weeks before the first written national test in mathematics in year t, as specified in equation (2). $\mathbf{Z}'_{st}$ is a vector of time-variant school characteristics including the share of students with foreign background, the share of students with higher education background, the share of female students and the number of students in grade six. θ_m and γ_t represent municipality- and year-fixed effects, respectively. All regressions are estimated with standard errors clustered at the municipality level.

In specification (3), ψ_s is a dummy variable that takes the value 1 for schools that have experienced at least one shooting within 1,000 meters, in any time and year before the first written national test in mathematics is taken (i.e., not just during the five weeks before the first test, but anytime in the past). This dummy is included in the regression because, as earlier described, gun violence tends to occur more frequently in neighborhoods characterized by factors such higher unemployment, ethnic segregation, low levels of income and cramped housing conditions in Sweden. The inclusion of a post exposure-dummy for whether gun violence has ever occurred in proximity to school *s* before the first written national test in mathematics is thus done under the assumption that exposure to gun violence in the past can be used as a proxy for factors that are different across schools that have been exposed to a shooting just before the national tests in mathematics and schools that have not.

Furthermore, by including a variable that indicates whether school *s* has experienced gun violence before the national tests in any year over the period from 2018 to 2022, specification (3) does not only examine the short-term impact of gun violence, but also makes it possible to consider the more long-term consequences of such violence.

Examining the impact over a longer time period might however lead to the potential problem of "bad controls", i.e., control variables that could be affected by the occurrence of a shooting, which must be taken into account (see e.g., Angrist & Pischke, 2008). For example, if gun violence takes place close to a certain primary school, it is possible that some parents become worried about their child's safety and choose to move their kid to a school in another location. Moreover, some families might decide to move away from areas that are affected by gun violence. The ability to do so does however depend on factors such as income and contacts, implying that the probability of school transferring is likely to vary across students. For example, it is almost six times more common to have a low income standard[12] among children with a foreign background compared to children with a Swedish background (Statistics Sweden, 2022). Thus, after a shooting has occurred, families with a Swedish background might have more resources that can be used for moving away from a violent area compared to families with a foreign background.

Moreover, having a post-secondary education is generally associated with a higher income (e.g., OECD, 2022), implying that parents with higher education might move away and have their children transfer schools from areas where shootings occur to a larger extent than low-education parents. If that is the case, including control variables such as the share of students with foreign background and the share of students with a higher education background would be to control for variation that is in fact due to exposure to gun violence itself. Given this risk, this thesis starts the analysis without school unit-fixed effects by estimating a simple benchmark specification with only municipality and year fixed effects. Control variables are then added one at a time to examine how the relationship changes (see section 6.2).

[12] Having a low income standard is defined as "living in households not able to meet basic needs, such as housing costs, costs of child care, local transportations etc." (Statistics Sweden, 2022, Definitions and explanations section).

6 Results

In this section, the results of estimating the relationship between exposure to gun violence and students' educational outcomes are presented. The first part focuses on the impact of shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written mathematics test is taken. The analysis starts with estimating the model with school fixed effects in equation (1), and then investigates the model without school fixed effects from specification (3) in subsection 6.1.1. The second part investigates robustness in the main analysis and the third part examines heterogeneous effects with respect to gender.

6.1 Main results

Table 2 presents the regression results from estimating the relationship between exposure to gun violence and total mathematics test scores (share passing the mathematics exams) for students in the sixth grade of primary school. In the first column, the relationship between fatal and non-fatal gun violence and the total mathematics test score is estimated with school and academic year fixed effects, without further controls. In column two, a set of school and student characteristics are included as controls.[13] The third and fourth columns present the estimated relationships from regression with only person-hit shootings with and without school controls, respectively.

Overall, the results presented in columns 1-4 of Table 2 imply a negative relationship between gun violence and the total mathematics test score. In the simplest specification without controls (column 1), exposure to gun violence is associated with a reduction in mathematics test scores by approximately 0.27 points. Adding control variables to the regression in column 2 lowers the magnitude of the estimate slightly and reduces the statistical significance of the coefficient. This is however explained by the change in sample size that occurs when controls are included in the model, as is shown in Appendix A.3 in this thesis. The estimate in column 3, which reflects the relationship between shootings with victims and mathematics test scores, is larger in magnitude and significant at the 5% level. As when all shootings (with and without victims) are included in the analysis, adding school and student controls to the regression reduces the magnitude of the estimate slightly (column 4), but this change is to a large extent explained by the change in sample across column 3 and 4 (see Appendix A.3).

To get a sense of the mechanisms that underlie the results, Table A.2 in Appendix A reports how the observed outcome and relationship with exposure to gun violence changes when the different control variables are added to the analysis one at a time. As can be seen there, the negative relationship remains stable when controls for the number of students in sixth grade and the share of female students are added to the regression. The share of students with foreign background and the share of students with higher education background seem to be most important out of the control variables for explaining variations in the mathematics test results. Especially the inclusion of a control variable for the share of students with foreign background seems to be associated with a drop in effect size in Table A.2.

In columns 5-8 the exercise is repeated with the share of students that passes the national tests in mathematics as the dependent variable. Column 5 presents the estimated relationship

[13] See the table notes for a description of the controls.

between fatal and non-fatal gun violence and the share of students that pass the mathematics exams, with school and academic year fixed effects, but without further controls. The specification in column 6 includes a set of school and student characteristics. Finally, columns 7 and 8 present the estimated relationship between person-hit shootings and the share of students that pass the mathematics exams, with and without school controls, respectively.

Across the specifications in columns 5-8 in Table 2, the estimates imply a negative relationship between the probability of passing the national mathematics exams and exposure to a shooting. For example, the estimate in column 5 implies that experiencing at least one shooting during the five weeks before the first written national test in mathematics is taken is associated with lowering the share of students that passes the national exams in mathematics by approximately 1.95 percentage points. The negative relationship is robust to including control variables (columns 6 and 8), and statistically significant at least at the 10% level across all specifications. The results in columns 7 and 8 in Table 2 also imply that the relationship is larger in magnitude, as well as more precisely estimated, when only person-hit shootings are considered compared to when both no-person-hit and person-hit gun violence is included in the analysis. In column 8, the estimated coefficient implies that experiencing at least one person-hit shooting during the five weeks before the first written national test in mathematics is taken is associated with reducing the share of students that passes the national mathematics exams by approximately 4.15 percentage points. Thus, the relationship between exposure to gun violence before the national test and the test results appears to be more than twice as large in magnitude when only person-hit-shootings are taken into account compared to when all gun violence is included in the analysis.

Lastly, as described in section 4.1 of this thesis, 102 of the shootings considered in the previous analyses have been manually imputed because they do not have correct coordinates in the data from the National Swedish Police. To show that the manual imputation of approximate coordinates does not drive the results in the analysis, the main regressions are run without the manually imputed shootings in Appendix A.2. As can be seen there, excluding the shootings with manually imputed coordinates does not change the results in Table 2 noteworthy.

TABLE 2. The relationship between exposure to gun violence and educational outcomes.

	Average total mathematics test score (max = 20)				Share passing exam (0 - 100)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.2702*** (0.1022)	-0.2189* (0.1123)	-0.5497** (0.2402)	-0.4774* (0.2541)	-1.9542** (0.9116)	-1.7469* (0.9540)	-4.3277*** (1.5801)	-4.1472*** (1.5583)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Shootings included	All	All	With victims	With victims	All	All	With victims	With victims
N	8,795	7,574[14]	8,795	7,574	8,388	7,313	8,388	7,313
R^2	0.6762	0.7072	0.6764	0.7074	0.5838	0.5920	0.5842	0.5925
Adjusted R^2	0.5611	0.5937	0.5613	0.5939	0.4354	0.4341	0.4360	0.4348

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' educational outcomes. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

[14] The change in sample size across regressions with and without control variables in Table 2 is due to missing data points in the control variables. In Appendix A.3 it is shown that the changes in coefficient size between regressions with and without controls are to a large extent explained by changes in sample.

6.1.1 Estimations without school unit-fixed effects

As described in section 5.2, the specification that is used in the main analysis of this thesis is relatively demanding as no between-school variation can be exploited in the analysis. Such variation might however be important to identify the relationship between gun violence and educational outcomes, which is investigated by estimating the less demanding specification (3) in this section. The primary purpose of the analysis in this part is to get a picture of the mechanisms that underlie the observed results in the main analysis.

Table 3 presents the regression results from estimating the relationship between gun violence with and without victims and total mathematics test scores for students in sixth grade, without school unit fixed effects. Column 1 shows the results from regression with only the variable for past exposure to gun violence in any year and time before the first written national test in mathematics is taken, as regressor. As can be seen there, the estimate is negative and statistically significant at the 1% level.

As previously stated, there is a risk that the control variables in specification (3) are themselves affected by incidents of gun violence around schools. In order to examine this possibility, columns 2-6 report how the estimated relationship between exposure to gun violence just before the first written national test in mathematics is taken and students' educational outcomes, is affected when each control variable is included in the analysis. In all five columns, the estimates in Table 3 imply a negative and statistically significant relationship at least at the 10% level between exposure to gun violence close in time to the national tests and the total mathematics test score, and the signs of the control variables are as expected. Out of the control variables, the share of students with foreign background and the share of students with higher education background seem most important for explaining variation in the total mathematics test score, as implied by the R^2-indicators at the end of Table 3.

Column 7 finally presents the results from estimating specification (3) with a full set of controls. As in the main analysis, the estimated coefficient for exposure to gun violence during the five weeks before the first written national test in mathematics is negative. The estimate is smaller in magnitude compared to in the main analysis, and not statistically significant. Likewise, the estimated coefficient for the control for past exposure to gun violence is statistically insignificant and smaller in magnitude compared to the coefficient for exposure to gun violence just before the written mathematics tests.

TABLE 3. Estimation without school unit-fixed effects.

	Average total mathematics test score (max = 20)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Past exposure to shooting	-0.7045***	-0.5654***	-0.5737***	-0.5616***	0.1598	-0.1229	-0.0508
	(0.1087)	(0.1379)	(0.1450)	(0.1420)	(0.1128)	(0.1189)	(0.0993)
Shooting just before test		-0.9807***	-0.9542***	-0.9930***	-0.3725*	-0.2498*	-0.1736
		(0.3691)	(0.3606)	(0.3704)	(0.2004)	(0.1466)	(0.1491)
Number of students in 6th grade			0.007***				0.0010
			(0.0021)				(0.0010)
Share female students				0.0127**			-0.0074
				(0.0064)			(0.0082)
Share with foreign background					-0.0526***		-0.0153***
					(0.0026)		(0.0030)
Share with higher education background						0.0843***	0.0711***
						(0.0030)	(0.0042)
School fixed effects	No	No	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	8,795	8,795	8,753	8,765	7,588	8,728	7,574
R^2	0.2060	0.2093	0.2142	0.2094	0.4032	0.4400	0.4795
Adjusted R^2	0.1792	0.1824	0.1872	0.1823	0.3796	0.4208	0.4587

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' test scores. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include municipality and time fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

6.2 Robustness tests

To examine if the results in the main analysis of this thesis are dependent on the particular definition of violence that is used, the baseline regression in equation (1) is re-run with alternative definitions of exposure to gun violence. The first alternative definition uses a radius that is slightly smaller than in the benchmark specification, capturing shootings that occur within a 900-meter radius around Swedish primary schools. The second one uses a radius that is slightly larger and captures gun violence within a 1,100-meter radius of primary schools. After this, the exposure period, i.e., the number of days before the first written national test that is considered in the main analysis, is varied to include either three less or three more days. The results from these exercises are presented in Table 4 and 5 below.

Like when a 1,000-meter radius is used (see the results in section 6.1), the estimated coefficients in Table 4 are all negative. As in the main analysis, the signs of the estimates imply a negative relationship between gun violence and students' educational outcomes. When the smaller radius of 900 meter is employed, the magnitude of the effect seems to be larger compared to when the baseline 1,000-meter radius is used. The estimates are statistically significant in all columns but column 2, possibly because too few schools were exposed to shootings with victims within the smaller radius. Estimation with the larger 1,100-meter radius instead leads to a reduction in statistical significance, coefficient and effect size compared to in the main analysis. There does however still seem to be a negative relationship between shootings with victims and the probability of passing the national mathematics exams that is statistically significant at the 5% level (column 8).

Taken together, the estimates in Table 4 indicate that the magnitude of the association between exposure to gun violence and students' educational outcomes varies with distance to violence. The relationship seems to be stronger for schools that are located closer to places where gun violence has occurred, implying that the educational consequences of shootings might decrease with distance between the school and the shooting, as expected. This interpretation should however be made with caution due to the relatively small number of exposed school units when the 900-meter radius is used, and the statistically insignificant estimates in Table 4.

Table 5 reports the results from estimation with a slightly shorter (left panel) and slightly longer (right panel) exposure period. As in the main analysis, the coefficients are all negative, indicating a negative relationship between exposure to gun violence and students' total mathematics test scores. The estimates for the shorter exposure period in the left panel of Table 5 are larger in magnitude compared to in the main analysis and to the longer exposure period in the right panel. For example, the estimates in columns 1 and 2 imply that exposure to gun violence during the 32 days before the first written test in mathematics is associated with a reduction in the total mathematics test score by approximately 0.29 and 0.24 points, respectively. These numbers can be compared to 0.27 and 0.22 in the main analysis (see Table 2). The estimated coefficients for the three days longer exposure period in the right panel of Table 5 are in contrast smaller in magnitude, both compared to in the baseline analysis and compared to the estimates in the left panel, and only statistically significant in column 5. Thus, as in the studies from Latin America (see Michaelsen & Salardi, 2020; Monteiro & Rocha,

2017) the relationship between exposure to gun violence and students' educational outcomes seems to be relatively short-term, even if this interpretation should only be done with caution.

Finally, to test if the results obtained in the main analysis are biased by unobserved components that are correlated with the probability of gun violence occurring close to a primary school and the school's mathematics exam results, this thesis also performs a placebo test as is common in the literature (see e.g., Monteiro & Rocha, 2016; Michaelsen & Salardi, 2020). Specifically, this thesis examines the relationship between shootings that occur during the 35 days that follow the second week *after* the last mathematics test is taken and performance on the national mathematics test. If increases in gun violence in proximity to Swedish primary schools is not a result of underlying factors that have been omitted from the analysis, no adverse effects should be observed for the measure of gun violence in the specification, as future changes in gun violence should not predict test results that students have already obtained. The choice to use a period that starts from the second week after the exams rather than the first has been made because data on shootings that occur immediately after the test could be misleading if such shootings are reflected by a higher level of threats, tension and/or violence within the neighborhood just before the exam. As reported in Table 6, this thesis finds no evidence of an association between gun violence after the exams and the test results.

Taken together, the robustness tests performed in this section indicate that the results obtained in the main analysis are to some extent dependent on factors such as the distance between shootings and schools and the time period before the first written national test in mathematics that is examined. The estimated association seems to be stronger when a shorter time period is considered in the analysis and when a smaller exposure radius is used. The signs of the estimates are however negative in all regressions and for all measures of exposure, implying a negative relationship between exposure to gun violence and students' educational outcomes, no matter which definition of exposure that is used.

TABLE 4. The estimated relationship between gun violence and educational results for a 900- and 1,100-meter exposure radius.

	Average total mathematics test score (max = 20)				Share passing exam (0 - 100)			
	900 m		1,100 m		900 m		1,100 m	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.2398**	-0.3942	-0.0518	-0.2127	-2.1533***	-3.9447**	-1.1624	-3.4135**
	(0.0954)	(0.2868)	(0.1171)	(0.2588)	(0.7349)	(1.5484)	(0.7402)	(1.4392)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shootings included	All	With victims	All	With victims	All	With victims	All	With victims
N	7,574	7,574	7,574	7,574	7,313	7,313	7,313	7,313
R^2	0.7072	0.7072	0.7071	0.7071	0.5921	0.5923	0.5919	0.5923
Adjusted R^2	0.5937	0.5937	0.5935	0.5936	0.4343	0.4346	0.4339	0.4346

Notes: The variable shooting implies the relationship between shootings that occur within a 900- and 1,100-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' educational outcomes. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

TABLE 5. The estimated relationship between exposure to gun violence and mathematics test scores for alternative exposure periods.

	Average total mathematics test score (max = 20)							
	32 days				38 days			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.2883** (0.1192)	-0.2366** (0.1184)	-0.4955* (0.2543)	-0.4197 (0.2656)	-0.1871** (0.0860)	-0.1345 (0.0935)	-0.2095 (0.2001)	-0.1366 (0.2149)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Shootings included	All	All	With victims	With victims	All	All	With victims	With victims
N	8,795	7,574	8,795	7,574	8,795	7,574	8,795	7,574
R^2	0.6762	0.7072	0.6763	0.7073	0.6761	0.7071	0.6761	0.7071
Adjusted R^2	0.5611	0.5937	0.5612	0.5938	0.5610	0.5935	0.5609	0.5935

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the 32 days (left panel) and 38 days (right panel) before the first written national mathematics test is taken and students' test scores. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

TABLE 6. Placebo test.

	Average total mathematics test score (max = 20)		Share passing exam (0 - 100)	
	(1)	(2)	(5)	(6)
Shooting just before test	-0.1011 (0.1522)	-0.2198 (0.1666)	0.2758 (0.9618)	-1.1908 (1.1429)
School fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Shootings included	All	With victims	All	With victims
N	7,574	7,574	7,313	7,313
R^2	0.7071	0.7071	0.5917	0.5918
Adjusted R^2	0.5935	0.5936	0.4337	0.4338

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the five-week period that starts the second week after the last national mathematics test is taken. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

6.3 Heterogeneity analysis

As described in section 2.2 in this thesis, previous literature has documented that the impact of exposure to violence can lead to significant differences in economic outcomes across the genders (e.g., Shemyakina, 2011; Valente, 2014). To investigate this possibility in the Swedish setting, the relationship between exposure to gun violence and the total mathematics test score is estimated separately for girls and boys, and the results are shown in Table 7. All specifications include time and school fixed effects, and as in the main analysis, the estimates are reported both with and without a full set of controls (see the table notes). The left panel of Table 7 presents the results for the girls-sample, with the results from regression with all shootings in column 1 and 2, and the results from regression with only shootings with victims in columns 3 and 4. The right panel of Table 7 presents the corresponding results for the sample of boys, with estimates from regression with all shootings in columns 5 and 6 and estimates from regression with only shootings with victims in columns 7 and 8.

Overall, the estimated coefficients in Table 7 imply a negative relationship between exposure to gun violence and the mathematics test scores for both girls and boys. When all shootings with and without victims are considered, this association is not statistically significant. However, when only shootings with victims are included in the analysis, the estimates in Table 7 imply a more pronounced and statistically significant negative relationship. More specifically, increasing the number of shootings with victims before the first written national test in mathematics by one is associated with a reduction in total mathematics test scores among girls and boys by roughly 0.71 and 0.55 points, respectively (columns 4 and 8). Both estimates are significant at the 1% level. Overall, the estimates for girls are seemingly

larger in magnitude compared to the estimates for boys. Thus, girls might be more negatively affected from gun violence in proximity to Swedish primary schools than boys. However, as the confidence intervals for the estimated relationship between exposure to gun violence and educational performance overlaps for girls and boys, no definite conclusions should be drawn from the estimates in Table 7.

TABLE 7. The relationship between gun violence and educational results – heterogeneous analysis by gender.

	Average total mathematics test score (max = 20)							
	Girls				Boys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.3192 (0.1953)	-0.2997 (0.2113)	-0.7143*** (0.2416)	-0.7054*** (0.2425)	-0.2280 (0.1701)	-0.2042 (0.1614)	-0.5575*** (0.1765)	-0.5502*** (0.1620)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Shootings included	All	All	With victims	With victims	All	All	With victims	With victims
N	6,174	5,808	6,174	5,808	6,355	5,963	6,355	5,963
R^2	0.6784	0.6907	0.6787	0.6910	0.6612	0.6731	0.6614	0.6733
Adjusted R^2	0.5597	0.5706	0.5601	0.5711	0.5365	0.5466	0.5368	0.5470

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' test scores. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

7 Discussion and conclusions

In recent years a surge in the number of shootings in Sweden has received considerable attention, but despite this, relatively little has been known about the consequences of such violence, which potentially go beyond the casualties of the people involved in criminal activity and its victims. Against this background, this thesis aims to examine how the gun violence in Sweden affects students' educational outcomes. More specifically, it studies the relationship between shootings that occur in proximity to Swedish primary schools and students' results on the national tests in mathematics, using a sample of 2,304 schools covering the period between the school years 2016-2017 and 2021-2022.

The results in this thesis provide evidence that gun violence in Sweden has negative spillover effects on the population by demonstrating a negative relationship between gun violence and students' educational outcomes. In particular, exposure to gun violence during the five weeks before the first written national test in mathematics is taken, is associated with reducing the average total test score and the share of students that passes the national tests in mathematics. The thesis also presents suggestive evidence that the magnitude of the association varies with timing and distance between the school and the shooting, even if no definite conclusions can be drawn on this matter.

Heterogeneity analysis by gender implies a stronger relationship between exposure to gun violence and educational performance when only person-hit shootings are considered among both boys and girls. The magnitude of the association seems to be stronger among girls, even if this interpretation should only be made with caution. Even if no definite conclusions can be drawn, it is possible that the opportunity cost of attending school is impacted differently across the genders after a shooting has occurred. Since boys are more likely to be targeted for involvement in gun homicides, male students might experience a larger increase in the opportunity cost of attending school when information about likely victimization is revealed from a shooting. The students that this paper focuses on are however relatively young, and less likely to be targeted for recruitment and involvement in gun homicide compared to older students. Consequently, if the impact of gun violence is heterogeneous with respect to gender, it is possible that the resulting gender difference in educational outcomes is more pronounced among older students. This possibility and its implications must however be examined further in future work before any certain interpretations can be made.

An important question is whether the effect of gun violence on test scores is transitory, or if the shootings in Sweden also have broader negative consequences for student learning that are more permanent. For instance, acute psychological stress from gun violence might lead to a reduction in study time prior to exams, which potentially reduces students' internalization of knowledge from the preceding school year. Moreover, as far as exam scores shape students' future educational possibilities – e.g., admission to better schools and more advanced education – exposure to gun violence, that leads to reduced exam performance, could have a negative impact on the ability to accumulate education among affected students. Although students' grades in year six do not officially affect their educational opportunities in Sweden, there are potential future risks associated with lower grades. For instance, a majority of the students in Sweden that receive more than one fail grade in year six do so in year nine as well (National

Education Agency, 2017). In this way, the grades that students obtain already in year six can play a role in shaping students' opportunities in the future.

Moreover, the findings in this paper suggest that the negative consequences of shootings near schools might disproportionately affect students in socially disadvantaged neighborhoods, as gun violence occurs more frequently there. From a short-term perspective, the educational outcomes among students in such areas might suffer larger consequences of gun violence compared to students that go to schools in areas that are not exposed to shootings. There might also be more long-term consequences of gun violence that harms educational outcomes in such areas further. For example, over time, families might choose to transfer their children from schools that have been exposed to gun violence to schools that have not. Although the option of school transferring is available to all families in Sweden, the empirical evidence shows that it is mostly utilized by students with parents of high socioeconomic status (Brandén & Bygren, 2022; Böhlmark et al., 2015; National Agency for Education, 2003). Thus, it is likely that the students that choose to change school after a shooting has occurred will disproportionately be students with relatively high economic status, which will in turn reduce the average educational outcomes in the schools that are affected.

On the supply-side, teachers might choose to move away from schools that have been exposed to shootings. This should be particularly true for the teachers that have the most education, as they might face better outside options and possibilities to be productive. To the extent that high-quality teachers leave schools that are exposed to shootings, schools located in socially disadvantaged areas will again suffer the largest consequences, as gun violence occurs more often there. In this way, the negative effects from exposure to gun violence might amplify the disadvantages for those attending schools in more violent areas further.

The negative effects on educational outcomes from exposure to gun violence that are found in this thesis suggest that the design and implementation of policies should consider the risk for gun violence to disrupt students' educational performance, and the need to develop strategies to handle incidents of shootings once they have occurred. Schools that are affected by shootings in their nearby area might need more resources and plans to be able to offer counselling support to students that have been exposed to gun violence. Another implication is that the design and implementation of policy should consider ways to retain high-quality teachers in schools that are exposed to shootings, for example by offering higher wages in order to compensate teachers for the nonpecuniary disadvantages that are associated with exposure to violence.

In summary, the findings in this paper indicate that the gun violence in Sweden may have consequences for academic achievement that have previously been overlooked. By reducing students' test scores and probability of passing the national tests in mathematics, gun violence may lead to worse educational outcomes and less investment in human capital accumulation. These are costs to be added to all the other documented negative consequences of the gun violence in Sweden.

Appendix A

A.1 Exploring mechanisms in the main analysis

To explore mechanisms from the main analysis, the most simple regression without any control variables is first re-estimated, with the total average mathematics test score as the outcome variable and with all shootings included in the regression. Then, the control variables from the main analysis are added to the specification one at a time to explore how each of them relates to the average mathematics test score. Table A.1 presents the results from this analysis. As can be seen there in columns 4-6, the share of students with foreign background and the share of students with higher education background seem to be most important out of the control variables for explaining variations in the mathematics test results. The estimates imply that a larger share of students with foreign background is associated with a lower mathematics test result, while having a larger share of students with higher education background is associated with higher average mathematics test scores.

TABLE A.1. Exploring mechanisms in the main analysis.

	Average total mathematics test score (max = 20)					
	(1)	(2)	(3)	(4)	(5)	(6)
Shooting just before test	-0.2702*** (0.1022)	-0.2717*** (0.1021)	-0.2722*** (0.1018)	-0.2127* (0.1137)	-0.2487** (0.1078)	-0.2189* (0.1123)
Number of students in 6th grade		0.0027 (0.0026)				0.0026 (0.0025)
Share female students			0.0134 (0.0091)			0.0113 (0.0010)
Share with foreign background				-0.0235*** (0.0071)		-0.0152* (0.0084)
Share with higher education background					0.0402*** (0.0078)	0.0327*** (0.0010)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Shootings included	All	All	All	All	All	All
N	8,795	8,753	8,765	7,588	8,728	7,574
R^2	0.6762	0.6764	0.6763	0.7054	0.6806	0.7072
Adjusted R^2	0.5611	0.5604	0.5606	0.5917	0.5659	0.5937

Notes: The variable shooting implies the relationship between of shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' test scores. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

A.2 Estimation without manually imputed shootings

Table A.2. presents the results from re-estimating the main regressions from Table 2 without the manually imputed shootings. As can be seen there, excluding the shootings that were either missing or incorrectly reported in the datafile from the National Police Authority does not change the sign or statistical significance of the estimates obtained in the main analysis.

TABLE A.2. The relationship between exposure to gun violence and educational outcomes. Only shootings with correctly reported GPS coordinates are included in the analysis.

	Average total mathematics test score (max = 20)				Share passing exam (0 - 100)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.2673*** (0.1044)	-0.2152* (0.1148)	-0.5513** (0.2473)	-0.4771* (0.2621)	-1.9861** (0.9180)	-1.7666* (0.9637)	-4.4702*** (1.6132)	-4.1472*** (1.5583)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Shootings included	All	All	With victims	With victims	All	All	With victims	With victims
N	8,795	7,574	8,795	7,574	8,388	7,313	8,388	7,313
R^2	0.6762	0.7072	0.6764	0.7073	0.5838	0.5920	0.5843	0.5925
Adjusted R^2	0.5611	0.5936	0.5613	0.5939	0.4354	0.4341	0.4361	0.4348

Notes: The variable shooting implies the relationship between shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken and students' educational outcomes. Only shootings with correct GPS coordinates in the raw data file are included in the analysis. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

A.3 Estimation without changing the sample size

Table A.3 shows the results from re-estimating Table 2 without changing the sample size. Compared to in the main analysis of this thesis, the difference in magnitude across regressions with and without control variables is smaller when only the observations that do not miss any data points for any of the control variables are included in the analysis.

TABLE A.3. The relationship between exposure to gun violence and educational outcomes without changing the sample size.

	Average total mathematics test score (max = 20)				Share passing exam (0 - 100)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shooting just before test	-0.2176* (0.1122)	-0.2189* (0.1123)	-0.4754* (0.2535)	-0.4774* (0.2541)	-1.8046** (0.9641)	-1.7469* (0.9540)	-4.2038*** (1.6090)	-4.1472*** (1.5583)
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Shootings included	All	All	With victims	With victims	All	All	With victims	With victims
N	7,574	7,574	7,574	7,574	7,313	7,313	7,313	7,313
R^2	0.7046	0.7072	0.7047	0.7074	0.5881	0.5920	0.5886	0.5925
Adjusted R^2	0.5903	0.5937	0.5906	0.5939	0.4292	0.4341	0.4299	0.4348

Notes: The variable shooting implies the effect of shootings that occur within a 1,000-meter radius around Swedish primary schools during the five weeks before the first written national mathematics test is taken. Control variables are the number of students in sixth grade, the share of students with foreign background, the share of students with higher education background and the share of female students. All regressions include time and school fixed effects. Standard errors are clustered at the municipality level and reported in parentheses. ∗, ∗∗ and ∗∗∗ denote significance level of 10%, 5% and 1%, respectively.

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