Trends in paediatric firearm-related encounters during the COVID-19 pandemic by age group, race/ethnicity and schooling mode in Tennessee

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ABSTRACT

Background Increases in paediatric firearm-related injuries during the COVID-19 pandemic may be due to changes in where children and adolescents spent their time. This study examines changes in the frequency of paediatric firearm-related encounters as a function of schooling mode overall and by race/ethnicity and age group at a large trauma centre through 2021.

Methods We use data from a large paediatric and adult trauma centre in Tennessee from January 2018 to December 2021 (N=211 encounters) and geographically linked schooling mode data. We use Poisson regressions to estimate smoothed monthly paediatric firearm-related encounters as a function of schooling mode overall and stratified by race and age.

Results Compared with pre pandemic, we find a 42% increase in paediatric encounters per month during March 2020 to August 2020, when schools were closed, no significant increase during virtual/hybrid instruction, and a 23% increase in encounters after schools returned to in-person instruction. The effects of schooling mode are heterogeneous by patient race/ethnicity and age. Encounters increased among non-Hispanic black children across all periods relative to pre pandemic. Among non-Hispanic white children, encounters increased during the closure period and decreased on return to in-person instruction. Compared with pre pandemic, paediatric firearm-related encounters increased 205% for children aged 5–11 and 69% for adolescents aged 12–15 during the school closure period.

Conclusion COVID-19-related changes to school instruction mode in 2020 and 2021 are associated with changes in the frequency and composition of paediatric firearm-related encounters at a major trauma centre in Tennessee.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Firearm-related injuries and deaths among children and adolescents increased during 2020. Researchers suggest increases may be due to changes in where and how children and adolescents spent their time and other factors related to household firearm ownership.

WHAT THIS STUDY ADDS

⇒ This study expands research on this topic by extending the time frame through 2021 and explicitly testing the effects of schooling mode changes on the frequency of paediatric firearm-related encounters overall and by race/ethnicity and age group.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Given underlying differences in firearm access and intent of use by race/ethnicity and age, research on pandemic-related effects on firearm injury and death should examine differential effects of COVID-19 mitigation measures on paediatric firearm injury. Healthcare providers can help prevent paediatric firearm injury by regularly and consistently asking about firearm ownership and storage in patient encounters.

INTRODUCTION

From 2019 to 2020, firearm-related deaths among children and adolescents increased by almost 30%, making firearms the leading cause of death among young people in the USA.[1] Although this increase may be partially driven by prevailing trends,[2] other evidence suggests that some of this increase is related to the COVID-19 pandemic.[3–6]

The reasons for this increase remain underexamined empirically. Recent work proposes several potential drivers, including changes in where children spent their time; decreased parental supervision; increased firearm purchasing, neighbourhood violence and child abuse; and reluctance among adolescents to socialise outside the home.[7 8] This study examines whether changes in schooling mode (eg, in-person, virtual, hybrid, closed) are associated with changes in the frequency of paediatric firearm-related encounters overall and by race/ethnicity and age group at a large trauma centre in Tennessee.

Schooling mode provides a proxy measure of where and how children and adolescents spent their time during the pandemic. Changes in schooling mode may have increased risk of paediatric firearm injury by increasing time spent at home. About 40% of US children live in homes with at least 1 firearm. In Tennessee, nearly half (46% as of 2016) of households own a gun.[9] In over half of American gun-owning households, firearms are not stored locked and unloaded.[10] Firearm storage practices strongly predict risk of firearm homicide, suicide and unintentional injury among children and adolescents.[11]

The effects of changes in schooling mode on firearm injury may vary by race/ethnicity. While firearms are present for youth from all racial/ethnic backgrounds, white households with children are more likely to report owning a firearm compared with black households.[12 13] Firearm injury among white children and adolescents is more likely to

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occur in the home and be self-inflicted[14 15] or perpetrated by a parent/caregiver[16] compared with black children and is predicted by household firearm ownership.[2 12] However, both handgun ownership in black households and firearm suicide among black male adolescents have increased in recent years.[13] Some research finds differences in household firearm storage practices by race, with white households reporting less safe storage practices than black households.[17] School closures and virtual/hybrid schooling modes may have therefore differentially increased risk of exposure to firearms for white children and adolescents compared with black children and adolescents.

Conversely, in 2020, black adolescents were nearly 10 times more likely to experience firearm homicide than their white peers.[18] These disparities are the result of structural racism, which increases the likelihood that black adolescents live in neighbourhoods with concentrated poverty, unemployment, residential instability and gun violence.[19–21] Black children and adolescents have higher rates of firearm injury relative to the population that are increasing faster than other racial/ethnic groups.[2 15] In the context of the COVID-19 pandemic, risk of firearm injury among black children and adolescents may be less directly affected by schooling mode changes because black children and adolescents are exposed to firearms both in and out of the home.

Increased time at home may also have differential effects on firearm injury by age. For younger children aged 0–12, 85% of firearm deaths occur in the home.[14] While a majority of older children and adolescents who die by firearm are also shot in the home, fatal firearm homicides among adolescents aged 13–17 years are equally likely occur at home (39%) versus on the street/sidewalk (38%).[14] Pandemic-related changes to schooling that increased time at home may have increased accidental and unintentional firearm injuries among all ages, especially younger children. There may also have been changes in the frequency of firearm suicide among adolescents; however, research suggests that increased access to a firearm at home and worsening mental health may have increased firearm suicide[22 23] while disruption of bullying and academic stressors decreased firearm suicide among this age group.[24]

We advance the current literature by examining the effects of schooling mode on the frequency of paediatric firearm-related encounters overall and by age and race/ethnicity using data from a large paediatric trauma centre in Tennessee. We hypothesise that school closures differentially affected paediatric firearm encounters by race/ethnicity, with greater increases for white children, and by age, with greater increases for younger children.

METHODS

To examine changes in the frequency of paediatric firearm-related encounters, we used data on hospital and emergency department firearm-related encounters at Monroe Carell Jr. Children's Hospital at Vanderbilt University (MCJCHV) and Vanderbilt University Medical Center (VUMC). MCJCHV and VUMC are the only paediatric and adult Level I Trauma Centers in the Middle Tennessee region, an administrative region of Tennessee encompassing 33 counties and the most populous city, Nashville. MCJCHV and VUMC maintain a service area of 80 000 square miles, which is home to 1.25 million children in 79 counties across Tennessee, southern Kentucky and northern Alabama.

Trauma patients under age 16 are triaged to the pediatric emergency department at MCJCHV. Trauma patients aged 16 or 17 years old who have life-threatening injuries may be triaged to the adult emergency department at VUMC.

Study cohort

We queried the institutional database of patient encounters for initial firearm-related emergency department encounters at both hospitals from 1 January 2018 through 31 December 2021. Because firearm-related diagnosis codes are used inconsistently, encounters were initially identified via text search of 'gun', 'GSW', 'firearm' and variations in the Epic diagnosis field. Codes and diagnoses that suggested historical firearm-related injuries were excluded (eg, history of gunshot wound, healing gunshot wound). All diagnoses were manually reviewed by two members of the study team and diagnoses unrelated to firearm injuries were removed. This yielded 211 paediatric patients aged 5–17 years.

Measures

The primary outcome was the number of monthly paediatric firearm-related encounters overall, by race/ethnicity, and by age group. Monthly values were smoothed using 3-month moving average.

For each encounter, we also captured information on patient age, race, ethnicity, sex, diagnosis and billing ZIP code. Race was recorded as white, black or African American, other, unknown/missing, or refused. Ethnicity was recorded as 'Hispanic, Latino/a or Spanish', 'not Hispanic, Latino/a or Spanish', unknown/missing or refused. We coded race/ethnicity as 'non-Hispanic black', 'non-Hispanic white' and 'other' due to the small number of encounters among Hispanic/Latino children and adolescents (N=9). Encounters with missing data on race/ethnicity are included in overall and age stratified analyses.

We established the primary schooling mode for each month using MCH Strategic Data[25] for Fall 2020, Spring 2021 and Fall 2021 linked via ZIP-to-School-District crosswalk to our institutional encounter data. MCH schooling mode data have been used in studies of COVID-19 in K-12 schools in the USA.[26] In the USA, most K-12 schools closed by the weeks of 16 March or 23 March 2020 and remained closed or provided online schooling for the remainder of the school year.[27] During Summer 2020, about 60% of summer camps and community programmes for youth were closed across the USA.[28] In Fall 2020, school districts adopted a variety of schooling modes, with about half offering hybrid instruction, 24% online only and 17% in-person only.[25] Many districts also delayed the start of the 2020–2021 academic year by 1–6 weeks. Schooling mode remained varied in Spring 2021, with some of the country's largest districts remaining virtual for most or all of Spring 2021 while others reinstated in-person instruction between January and March.

In Tennessee, the timing of schooling mode changes for the largest public school districts is highly consistent with national trends. In Fall 2020, most districts adopted a hybrid or mixed mode of instruction. A minority offered in-person only instruction or online only instruction. Several districts delayed the start of the academic year, began the year fully online or closed due to COVID-19 cases in Fall 2020. In Spring 2021, most districts returned to in-person instruction by the end of the term.

Three-quarters (73%) of patients presenting to MCJCHV or VUMC for paediatric firearm-related encounter from 2018 to 2021 lived in 4 of Tennessee's 95 counties: Nashville-Davidson (53.7%), Rutherford (8.8%), Montgomery (5.6%) and Sumner (5.1%). Review of schooling mode for the school districts serving these four counties established the following timings: pre

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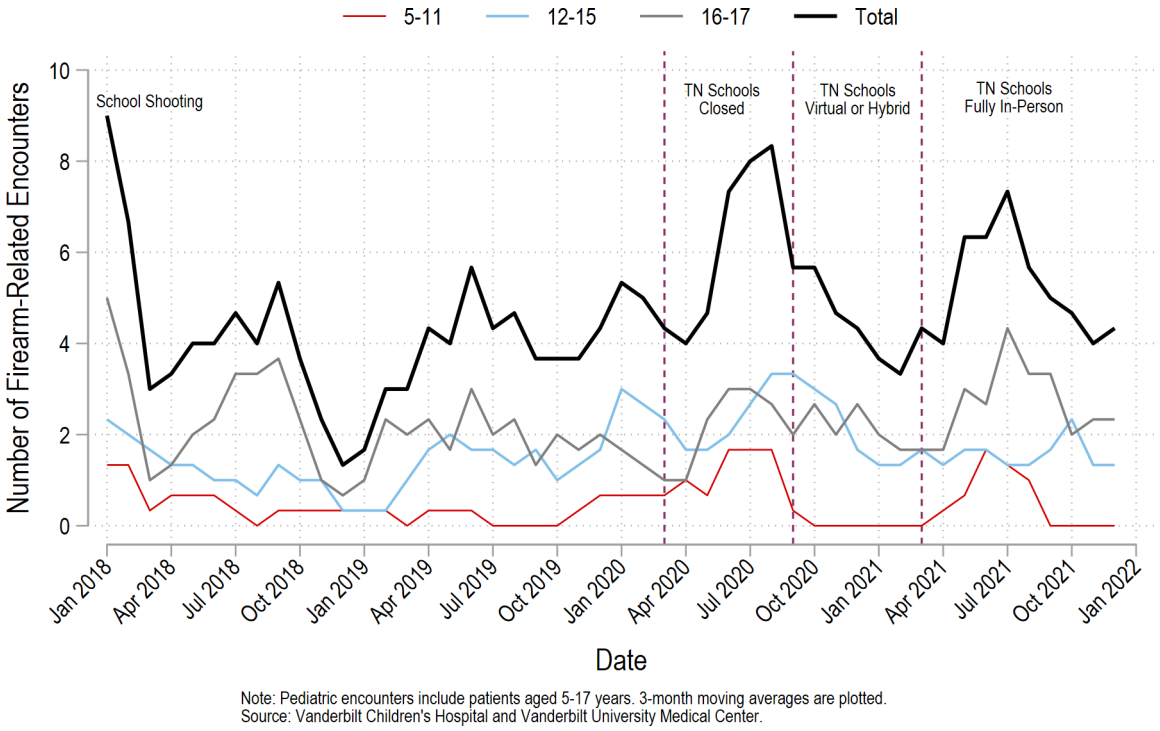

Figure 1 Monthly paediatric firearm-related encounters by schooling mode and age, 2018–2021. TN, Tennessee.

pandemic, January 2018–February 2020; closed, March 2020–August 2020; virtual/hybrid, September 2020–February 2021; in-person, March 2021–December 2021.

Analyses

All analyses were restricted to paediatric patients aged 5–17 years. We began with descriptive statistics and time trends. We then used a series of Poisson regressions with month-of-year fixed effects and robust standard errors to predict smoothed monthly paediatric firearm-related encounters as a function of schooling mode overall and stratified by race/ethnicity and age.

We tested for overdispersion in all models and consistently found that Poisson models are appropriate. Findings are robust to ±1 month shifts in the timing of school mode changes, the exclusion of March 2020 and the censoring of four encounters from a school shooting in Kentucky in January 2018 identified on figure 1 (see online supplemental appendix A).

Patient and public involvement

No patients were involved in the design or conduct of the research.

RESULTS

Table 1 presents patient characteristics for paediatric firearm-related encounters from January 2018 through December 2021. Consistent with national trends, most paediatric patients presenting for a firearm-related encounter were male across all time periods. Adolescents aged 16 and 17 comprised a majority of encounters in all periods except the school closure period (March to August 2020). Non-Hispanic black paediatric patients comprised an increasing share of encounters, growing from 41% in the prepandemic period to 62% following the return to in-person instruction in March 2021.

Figure 1 presents the 3-month moving average of monthly paediatric gunshot wound encounters from 1 January 2018 to 31 December 2021. Vertical lines indicate pandemic-related changes in the mode of instruction. In the prepandemic period, the trauma centre saw an average of 3.9 paediatric encounters among 5–17 year olds monthly. The trauma centre experienced an increase in paediatric firearm-related encounters during the school closure period in 2020 to an average of 5.6 encounters per month by late summer 2020. The 2020 peak is followed by a decline in encounters to 4.5 per month on average during the virtual/hybrid period, followed by a rise in encounters to 4.8 per month on average after return to in-person instruction in early Spring 2021.

Table 2 presents the predicted number of monthly paediatric firearm-related encounters and per cent change from prepandemic period controlling for month-of-year fixed effects overall and stratified by race/ethnicity and by age. Compared with the prepandemic period (January 2018–February 2020), the trauma centre saw a significant increase of 1.7 paediatric firearm-related encounters per month, a 42% increase over baseline ($p<0.001$), from March 2020 to August 2020 when schools and other youth activities were closed or cancelled. During the virtual/hybrid schooling period, the average number paediatric firearm-related encounters, 4.5 monthly, was not significantly elevated relative to baseline. During the in-person schooling period beginning in March 2021, paediatric firearm-related encounters increased by 0.9 encounters per month over baseline to 4.8 encounters on average, or 23% ($p<0.001$).

We observe differences in the direction and magnitude of schooling mode effects by race/ethnicity and age (see figure 2). Regression models stratified by race show that firearm-related encounters increased significantly relative to pre pandemic among non-Hispanic black patients in all periods by a substantial margin: 70% in the school closure period ($p<0.001$), 48% in the virtual/hybrid period ($p<0.05$) and 80% after the return to in-person instruction ($p<0.001$). For non-Hispanic white children and adolescents, firearm-related encounters increased 29% during the school closure period ($p<0.05$), were stable during the virtual/hybrid period and decreased 45% after the return

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Table 1 Demographic and encounter characteristics for paediatric firearm-related encounters, by schooling mode period

	Pre pandemic	Closed	Virtual/hybrid	In-person		
	January 2018–February 2020	March 2020–August 2020	September 2020–February 2021	March 2021–December 2021	Total	
	N (%)	N (%)	N (%)	N (%)	N (%)	P value
Total	104 (100)	33 (100)	27 (100)	47 (100)	211 (100)	
Age group						ns
5–11 years	11 (11)	8 (24)	0 (0)	5 (10)	24 (11)	
12–15 years	37 (36)	13 (39)	13 (48)	15 (32)	78 (37)	
16–17 years	56 (54)	12 (36)	14 (52)	27 (57)	109 (52)	
Sex						ns
Female	18 (17)	4 (12)	7 (26)	8 (17)	37 (18)	
Male	86 (83)	29 (88)	20 (74)	39 (83)	174 (82)	
Race/ethnicity						ns
Non-Hispanic black	43 (41)	16 (49)	14 (52)	29 (62)	102 (48)	
Non-Hispanic white	40 (39)	13 (39)	10 (37)	8 (17)	71 (34)	
Hispanic/Latino	6 (6)	2 (6)	1 (4)	0 (0)	9 (4)	
Other/multiracial	3 (2)	1 (3)	0 (0)	1 (2)	4 (2)	
Missing	13 (13)	1 (3)	2 (7)	9 (19)	25 (12)	

P vales reflect the significance of χ^2 tests.
ns, not significant.

to in-person instruction (p<0.001) relative to pre pandemic. Compared with all other groups, non-Hispanic white paediatric patients were significantly less likely to present for a firearm-related injury after schools returned to in-person instruction (p<0.05).

Regression models stratified by age show that paediatric firearm-related encounters increased significantly among children aged 5–11 and 12–15 during the school closure period. Compared with pre pandemic, paediatric firearm-related encounters increased by 205% for children aged 5–11 (p<0.001) and

Table 2 Predicted number of monthly paediatric firearm-related encounters and per cent change relative to pre-pandemic from adjusted Poisson models, overall and stratified by race/ethnicity and age group

				By race/ethnicity					
	Overall†			Non-Hispanic black			Non-Hispanic white		
School mode	Number per month	% change from pre pandemic	P value	Number per month	% change from pre pandemic	P value	Number per month	% change from pre pandemic	P value
Pre pandemic (January 2018–February 2020)	3.9	–		1.6	–		1.5	–	
Closed (March 2020–August 2020)	5.6	42	***	2.8	70	***	1.9	29	*
Virtual/hybrid (September 2020–February 2021)	4.5	15		2.4	48	*	1.8	19	
In-person (March 2021–December 2021)	4.8	23	***	3.0	80	***	0.8	–45	***

	By age group								
	Age 5–11			Age 12–15			Age 16–17		
School mode	Number per month	% change from pre pandemic	P value	Number per month	% change from pre pandemic	P value	Number per month	% change from pre pandemic	P value
Pre pandemic (January 2018–February 2020)	0.4	–		1.4	–		2.1	–	
Closed (March 2020–August 2020)	1.2	205	***	2.4	69	***	2.1	–2	
Virtual/hybrid (September 2020–February 2021)	0.1	–85		2.2	55	*	2.2	5	
In-person (March 2021–December 2021)	0.6	61		1.6	14		2.7	26	**

*p<0.05, **p<0.01, ***p<0.001.
†All models are predicted using a Poisson model with month of year fixed effects and robust standard errors.
*All models are predicted using a Poisson model with month of year fixed effects and robust standard errors.

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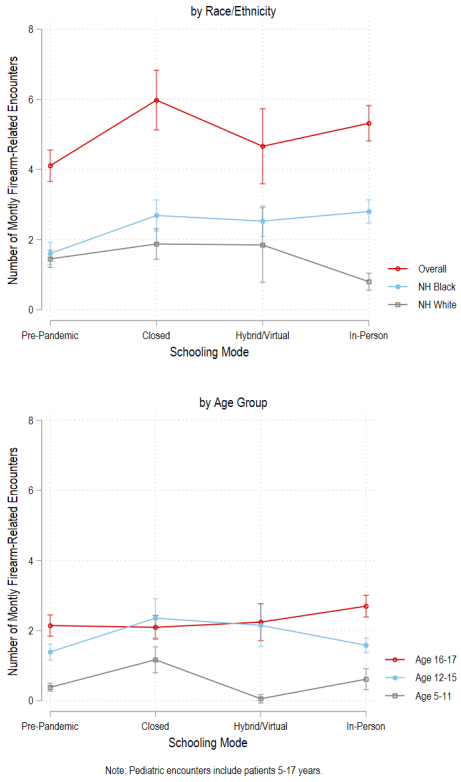

Figure 2 Predicted number of monthly paediatric firearm-related encounters by schooling mode, race/ethnicity and age, 2018–2021. NH, non-Hispanic.

69% for adolescents aged 12–15 ($p<0.001$) during the school closure period. The rate of encounters remained elevated during the virtual/hybrid period for adolescents 12–15 years old (55% increase relative to pre pandemic, $p<0.05$). Firearm encounters did not change relative to baseline among adolescents aged 16 and 17 until after the return to in-person instruction, where we observe a 26% increase in firearm encounters ($p<0.01$).

DISCUSSION

We examine trends in paediatric firearm-related encounters at a single centre from 1 January 2018 to 31 December 2021. Our analyses extend existing work by (1) linking information on schooling mode to examine associations with changes in the number of paediatric firearm-related encounters, (2) including the second full academic year of the pandemic and (3) stratifying by race/ethnicity and age group to assess diverging trajectories of firearm risk.

Trends in paediatric firearm-related encounters were closely tied to changes in schooling mode. The 42% increase in monthly paediatric firearm-related encounters during March 2020 to August 2020, when schools were closed and other youth activities cancelled, is highly consistent with the 38% increase in firearm-related encounters reported using data from the same period for 44 US children's hospitals in the Pediatric Health Information System database.[5] In Fall 2020, when most schools in the service area provided hybrid or virtual schooling, the rate of encounters was not statistically different from baseline. As students returned to in-person instruction in early Spring 2020, monthly paediatric firearm-related encounters again increased over the prepandemic period.

Importantly, however, the 23% increase observed during the return to in-person period obscures a divergence in the frequency of firearm injury by race/ethnicity. Although white and black children experienced more firearm injuries during the school closure period relative to prepandemic, firearm injuries decreased well below baseline (−45%) following the return to in-person instruction for white children while injuries continued to escalate for black children. Although prior work found no significant changes in the racial/ethnic distribution of paediatric firearm-related encounters from March 2020 to August 2020,[5] which our findings also support, we provide new evidence of diverging trajectories by race/ethnicity as the pandemic continued.

These findings are consistent with other work documenting greater and increasing risks of firearm injury death among black children and adolescents who experience a broader set of household and community gun violence risks.[2 29 30] While this study does not examine underlying causes, evidence has shown that socioeconomically disadvantaged neighbourhoods, a result of persistent structural and systemic racism, are associated with larger black–white disparities in firearm injuries and fatalities.[21] Many root causes of gun violence including income inequality, poverty and funding of public housing were exacerbated by the COVID-19 pandemic.[20 31]

We also find evidence of changes in the frequency of paediatric firearm-related encounters by age. The monthly number of encounters among children aged 5–11 and 12–15 increased significantly during the school closure period compared with pre pandemic. These findings are consistent with expectations that children and younger adolescents spent more time at home where a firearm may have been present during the pandemic. Firearm injuries and deaths in younger children are more likely to be unintentional shootings[2 14] and involve a firearm originating from either from the child's home or the home of a friend or relative.[32]

As schools returned to in-person instruction, encounters among 16 and 17 year olds increased by 26%. This is consistent with other work showing a 12%–18% increase in teen suicides following the return to in-person instruction in Spring 2021.[24] The apparent protectiveness of school closures and virtual/hybrid instruction for 16 and 17 year olds may reflect the accumulation of mental health challenges wrought by the pandemic that only became apparent over time, more frequent contact with family members, or the interruption of bullying and academic stressors by school closures and virtual/hybrid instruction.[23 24]

For children and adolescents living in a house with a firearm, storage practices matter. Research consistently finds that storing a firearm locked and unloaded and storing ammunition separately are independently effective practices for reducing self-inflicted and unintentional firearm injuries among children and adolescents.[14 32]

These findings highlight the pandemic as a critical opportunity to improve firearm safe storage counselling. Despite healthcare providers' understanding of the public health impact of firearm injuries and importance of counselling, many do not regularly or consistently ask about firearm ownership and storage in patient encounters.[33] Many barriers, including lack of time, uncertainty of the effect, inadequate training and perceived parental resentment, have been cited for decades.[34 35] However, most parents are generally open to these conversations,[36] and physician counselling has been shown to be effective in producing safer storage practices at home, especially when a secure storage device such as a cable gun lock is provided.[37–39] The American Academy of Pediatrics and others have recommended counselling about firearm safety and gun violence for over a decade.[40 41]

This study has limitations. As a single-centre study, the total number of paediatric firearm-related encounters observed is small (N=211), limiting generalisability to other areas or institutions. However, our findings are consistent with others documenting

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substantial increases in firearm injuries and deaths during the pandemic.[4–6] Additionally, we use the timing of schooling mode changes that applies to a majority of encounters, which may obscure finer variation for a minority originating from districts that returned to in-person instruction slightly earlier (mid-Fall 2020) or later (late-Spring or Fall 2021). Misclassification of race/ethnicity is unlikely to be random and may attenuate effects for non-Hispanic black children and contribute to few encounters observed among other minority groups. Last, we used schooling mode as a proxy for where and how children and adolescents spent their time. We are unable to observe how these changes affected parental supervision, intent, or other proposed determinants of increased firearm-related injury and death during the pandemic (eg, increased child abuse). Further, other mechanisms, including increased purchasing of firearms during the pandemic[3] and in response to other events (eg, Black Lives Matter protests and the 2020 National Election), may independently contribute to increased firearm injury and death during 2020.

CONCLUSION

The effects of pandemic-related school closures on paediatric firearm encounters among children 5–17 year olds are heterogeneous by race/ethnicity and age, reflecting underlying differences in household firearm ownership, safe storage practices and neighbourhood exposures to gun violence. There is a critical need to improve safe firearm storage in households with children and advance policies that address the root causes of gun violence in black communities.

Correction notice This article has been corrected since it was first published online. Table 2 has been updated.

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Patient consent for publication Not applicable.

Ethics approval This study was reviewed by the institutional review board at VUMC.

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