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Firearms Injuries Involving Young Children in the United States During the COVID-19 Pandemic

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Abbreviations:
- GVA: Gun Violence Archive
- NICS: National Instant Criminal Background Check System
- SAR: Semi-annual rates
- RR: Relative risk
- itsa: Interrupted time series analysis
- CI: Confidence interval
Table of Contents Summary: The COVID-19 pandemic is associated with a surge in firearm injuries in young children and inflicted by young children, correlating with increased firearm acquisitions.

What’s Known about this Subject: Firearms are a leading cause of injury and death among youth. Increased rates of firearm ownership, school closures and a suspected decrease in parental supervision during the COVID-19 pandemic may contribute to a surge in firearm injuries involving young children.

What This Study Adds: The COVID-19 pandemic is associated with a surge in fatal and nonfatal firearm injuries both in young children and inflicted by young children, correlating with a rise in firearm acquisitions. Strategies to prevent further injuries are urgently needed.

Contributors Statements:

Dr. Cohen conceptualized and designed the study, collected data, participated in data interpretation, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Goyal designed and conceptualized the study, oversaw the data analyses, and reviewed and revised the manuscript.

Dr. Donnelly substantially participated in conception and design of the study, data acquisition and reviewed and revised the manuscript for critically important intellectual content.

Dr. Patel made substantial contributions to conception and design and data interpretation and reviewed and revised the manuscript for critically important intellectual content.

Ms. Badolato substantially participated in conception and design of the study, designed the data collection instruments, substantially participated in data acquisition, analysis and interpretation and reviewed and revised the manuscript.

Ms. Boyle and Mr. McCarter substantially participated in conception and design of the study, data analysis and interpretation and reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.
Abstract

Objectives: Increased rates of firearm ownership, school closures and a suspected decrease in supervision during the COVID-19 pandemic place young children at increased risk of firearm injuries. We measured trends in firearm injuries in children and inflicted by children discharging a firearm during the pandemic and correlated these changes with a rise in firearm acquisition.

Methods: This was a cross-sectional study with an interrupted time series analysis using multi-year data from the Gun Violence Archive. We compared trends in 1) firearm injuries in children younger than 12 years old and 2) firearm injuries inflicted by children younger than 12 years old, during the pre-COVID period (March through August in the years 2016 to 2019) and during the first six months of the COVID-19 pandemic (March 2020 through August 2020). Linear regression models were developed to evaluate the relationship between firearm injuries and new firearm acquisitions.

Results: There was an increased risk of 1) firearm injuries in young children (RR=1.90; 95% CI 1.58, 2.29) and 2) injuries inflicted by young children (RR=1.43; 95% CI 1.14, 1.80) during the first six months of the COVID-19 pandemic as compared to the pre-COVID study period. These increased incidents correlate with an increase in new firearm ownership (p<0.03).

Conclusions: There has been a surge in firearm injuries in young children and inflicted by young children during the first six months of the COVID-19 pandemic. There is an urgent and critical need for enactment of interventions aimed at preventing firearm injuries and deaths involving children.
Introduction

In March 2020, the World Health Organization declared COVID-19 a global pandemic.\(^1\) In the absence of vaccination, physical distancing has become the primary means of curtailing viral spread.\(^2\) Taking cues from prior influenza epidemics, widespread school and recreational facility closures, intended to interrupt viral transmission, have led to children confined at home.\(^3\) In addition to increasingly recognized mental and physical health consequences of stay-at-home orders, children are also experiencing changes in home injury patterns.\(^4-7\)

Unintentional injury is the number one cause of death in children younger than 12 years of age.\(^8\) Firearm injuries account for more than one-quarter of all unintentional deaths among children in the United States.\(^8,9\) The COVID-19 pandemic has been associated with dramatic increases in firearm purchases\(^10\) and rates of firearm-related urban and interpersonal violence.\(^11,12\) There is an association of firearm ownership with increased rates of firearm injury, which may account for some of the increased rates of firearm violence.\(^10,11,13,14\)

People with children living in the home have been more likely to purchase firearms during the pandemic.\(^15\) Additionally, factors specific to children confined to the home, such as their natural curiosity and a suspected decrease in parental supervision during the pandemic, may also place young children at a heightened risk for firearm injuries. We hypothesized higher rates of firearm injury in young children and inflicted by young children discharging firearms, during the COVID-19 pandemic compared to previous years. Furthermore, we hypothesized that these increases correlate with a rise in new firearm acquisition.
Methods

Study Design and Data Source

This was a multi-year cross sectional study using data collected from the Gun Violence Archive (GVA). The GVA is a publicly available, real time repository of firearm injuries and deaths in the United States with incidents collected from over 7,500 law enforcement, media, government and commercial sources.16 We identified two distinct categories of injuries: 1) firearm injuries (both fatal and nonfatal) in children younger than 12 years of age; 2) firearm injuries (fatal and nonfatal) in any person inflicted by a child younger than 12 years of age during March through August of the years 2016-2020. Twelve years of age was used as an upper age limit to most accurately reflect accidental childhood injuries without including incidents during the adolescent years, when intentional firearm injuries and deaths may be more likely. The number of new background checks per 100,000 persons was used as a proxy for new firearm acquisitions.10 We used the Federal Bureau of Investigation’s publicly available National Instant Criminal Background Check System (NICS) to determine the number of new background checks during the study period. In the US, firearm dealers, manufacturers or importers who hold a firearms license are required to undertake a NICS background check on prospective buyers before transferring a firearm. We used data from US Bureau of Census for population estimates of children under 12 years of age. This study was considered exempt from Institutional Review Board review due to the use of publicly available data.

Data Analysis

We identified all firearm injuries in aggregate and by outcome (fatal and nonfatal) and calculated population-level rates of injury per 1,000,000 US children by month from March
through August in the years 2016 to 2020. We used the same months in each time period as comparatives to limit potential confounding from seasonal trends. We estimated firearm purchases over the same period based on the number of background checks by month and year. We evaluated trends in 1) firearm injuries (fatal and nonfatal) in children younger than 12 years of age; and 2) firearm injuries (fatal and nonfatal) in any person inflicted by a child younger than 12 years of age.

Poisson Regression, typically used to model data counts, was used to estimate rates per million in the population, and linear regression, used to model the relationship between two variables, was used to relate background checks to injury rates generated by the Poisson models. Using Poisson regression models, we tabulated semi-annual rates (SAR), rates of firearm injuries per million children in 6-month time intervals, March through August, for each study year 2016-2020. We calculated the relative risk (RR) of firearm injuries during the COVID-19 pandemic, March through August 2020, compared to March through August in the pre-COVID period, 2016 to 2019. We conducted an interrupted time series analysis (itsa) using the itsa procedure in STATA 14.2 to compare changes in the rates of firearm injuries from March through August in the pre-COVID period to during the first six months of the COVID-19 pandemic. The itsa procedure was used to define differences between the two time periods. The rates of gun injuries and deaths derived from Poisson regression model were juxtaposed with numbers of background checks in the same time periods and linear regression models were developed to evaluate the relationship between firearm injuries and new firearm acquisitions over the same period. For these analyses we do not differentiate between pre and post COVID time periods but measured the relationship between numbers of background checks and rates of gun injuries and deaths. The
proportion of the variance in firearm injuries explainable by firearm purchases is represented by the coefficient of determination ($r^2$). All analyses were performed using STATA version 14.2.

**Results**

*Firearm Injuries in Children Younger than 12 Years of Age*

During the study period there were 797 firearm injuries in children younger than 12 years, representing an overall rate of 16.43 firearm incidents per million US children. The majority of these incidents (525, 65.87%) were non-fatal (10.82 per million US children), while 272 (5.61 per million children) were fatal.

In the pre-COVID study period, there were 550 total firearm injuries in children younger than 12 years (average SAR = 2.8 per million). Of these, 183 were fatal (average SAR=0.94 per million) and 367 were nonfatal (average SAR=1.89 per million). During the 2020 COVID-19 pandemic, there were a total of 247 (SAR =5.09 per million) firearm injuries in children younger than 12 years. Of these, 89 were fatal (SAR=1.83 per million) and 158 nonfatal (SAR= 3.26 per million). Young children had a higher risk of total firearm injuries (RR=1.90; 95% CI 1.58, 2.29), nonfatal firearm injuries (RR=1.90; 95% CI 1.45, 2.51), and fatal firearm injuries (RR=1.89; 95% CI 1.41, 2.55) during the COVID-19 pandemic as compared to the pre-COVID years. Table 1 provides estimates of SAR during each pre-COVID year (2016-2019) and during the 2020 pandemic. The rate of change estimates in Table 1 were produced by itsa analysis and show consistency between the estimated rates of change and actual rates per time period determined by the Poisson regression analysis.
There was an increase in the rate of childhood firearms injuries during the first six months of the COVID-19 pandemic (March-August 2020) when compared to corresponding months in the pre-COVID period, 2016 to 2019. In the pre-COVID period, the rates of firearm injuries in children younger than 12 years old ranged from 0.30 to 0.68 per million children monthly and remained stable from year to year (p=0.79). From March 2020 to August 2020, the rates of firearm injuries in children younger than 12 years ranged from 0.52 to 1.20 per million children monthly. The rate of increase during the COVID-19 pandemic differed from the average pre-COVID period rate of change per month in total firearm injuries in children [0.128 vs. 0.001, p < 0.001]. (Figure 1a)

Firearm Injuries Inflicted by Children Younger than 12 Years of Age

During the study period there were 393 incidents of firearm injury inflicted by children under 12 years of age, representing 8.09 firearm incidents per million US children. Of these, 239 were nonfatal (4.93 per million) and 154 were fatal (3.17 per million).

In the pre-COVID study period, there were 287 total firearm injuries (average SAR 1.48 per million) inflicted by children, including 110 fatal injuries (average SAR= 0.57 per million) and 177 nonfatal (average SAR= 0.91 per million). During the COVID-19 pandemic, there were 106 firearm injuries inflicted by children (SAR=2.18 per million), including 44 fatal incidents (SAR=0.91 per million) and 62 non-fatal incidents (SAR=1.28 per million). There was a higher risk of firearm injuries inflicted by children during the COVID-19 pandemic (RR=1.43; 95% CI 1.14, 1.80). (Table 1)

There was an increase in the rate of firearms injuries inflicted by children less than 12 years old during the COVID-19 pandemic period as compared to the corresponding months in pre-COVID period. During the COVID-19 pandemic, the rate of increase of total injuries caused
by children discharging a firearm increased by 0.013 compared to a decline (-0.002) in the rate of firearm injuries inflicted by children in pre-COVID period. However, this change was not statistically significant. (Figure 1b)

**Association of Firearm Injuries with Firearm Acquisitions**

During the COVID-19 pandemic, the average number of new firearm acquisitions in units of 100,000 increased from a mean of 21.28 prior to the pandemic to a mean of 33.12 during the COVID-19 pandemic, representing an increase in new firearm acquisitions of 11.84 (95% CI 5.36, 18.32) per 100,000. (Figure 2) This increase in new firearm purchases correlates with the rise in firearm injuries in children younger than 12 years of age (r²=0.35, p=0.001) and with firearm injuries inflicted by children younger than 12 years of age (r²=0.16, p=0.029) during the COVID-19 pandemic. (Figure 3)

**Discussion**

We found a dramatic increase in firearm incidents involving young children during the first six months of the COVID-19 pandemic compared to the corresponding pre-COVID periods. This alarming trend was found both for fatal and nonfatal firearm injuries in children and for total and nonfatal firearm inflicted by children who discharged a firearm. Furthermore, these firearm injuries were correlated with increased firearm purchases during the COVID-19 pandemic period when compared to corresponding pre-pandemic months in 2016-2019.

The Council on Criminal Justice, a nonpartisan think tank, and many prominent news sources have reported an increase in gun violence and gun purchases during the pandemic. In addition, a recent analysis of data from the Gun Violence Archive which sought to measure the
relationship between firearm ownership and interpersonal gun violence, demonstrated an increase in overall gun violence during the pandemic that correlated with firearm purchasing. High levels of firearm ownership in the US coupled with a rise in firearm acquisition, likely contribute to an increase in firearm violence. Furthermore, factors specific to the pandemic, such as financial strain, psychosocial stress, and anxiety, may exacerbate the recent surge in gun violence. While prior studies have linked firearm availability to unintentional firearm deaths in children, to our knowledge, this is the first report to link the impact of increased firearm acquisition on young children during the COVID-19 pandemic.

While adolescent and adult firearm injuries are more likely to be intentional, firearm injuries and deaths in young children and inflicted by young children are often unintentional. Young children may be at particular risk for sustaining and inflicting unintentional injuries during the COVID-19 pandemic due to limited supervision. During the pandemic, there has been an overall decline in trauma rates; however, these effects have been either less pronounced or nonexistent in children. Some parents and guardians are working from home without the usual methods of child supervision such as daycare, in-person school, and organized recreation, and others who are required to be physically present at work may have no choice but to leave children at home without any supervision. In addition, increased parental and guardian substance use and addiction behaviors, and distracting social stressors within the home, such as unemployment and illness, may contribute to a surge in pediatric home injuries.

New firearm acquisitions correlate with increased rates of firearm injury and death in children. First time gun owners are encouraged to obtain firearm safety instructions regarding safe storage; however, stay-at-home orders likely limit access to firearm safety training. The lack of organized firearm safe storage training may result in more unsecured guns in homes which are...
more easily accessible to poorly supervised children. Required safety training for new firearm purchases, partnering with ranges or gun shops to promote safe storage, and increased public awareness of firearm safety may help to prevent unintentional firearm related incidents in the home.

Health care providers should ensure screening for firearm access and counsel families, while also providing tools for safe storage to restrict access to firearms for children. These interventions may be instrumental in preventing further unintentional firearm injury and deaths in young children. Additionally, while the only studied mass media campaign promoting safe firearm storage did not find any statistically significant effects on improving safe storage practices, historically public health messaging through media communication has been successfully employed to influence public health behaviors, such as smoking cessation and seatbelt use, and therefore, should be considered as a potential strategy. States should strongly consider enacting policy focused on firearm injury prevention, firearm safety training and safe storage. Further study of state-level firearm injury data, comparing states with and without stringent child access prevention laws, could help shed light on the efficacy of these laws in preventing firearm injuries involving children during the COVID-19 pandemic. Considering the immediate relevance, national policy should consider passing temporary firearm safety requirements amidst other measures with specific relevance to the pandemic. Moreover, these findings should trigger further study into the impact of multiple real and perceived stresses imposed by the current pandemic on the health and safety of children, particularly how it relates to injuries in the home.

There are some limitations to this study that should be considered. First and foremost, our study is reliant on national public archiving of data which may be incomplete and may be subject
to reporting bias, particularly as it relates to differential news and media reporting by region. Therefore, our data likely underestimate the total number of firearm injuries, particularly with regards to less severe firearm injuries and near misses without associated injuries. In addition, there are inherent limitations in the use of background checks reported to NICS as a proxy to estimate new firearm acquisitions. There is significant variation in state laws mandating background checks, with some states imposing new laws mandating background checks during the study period. This may have led to an overestimation of new firearm purchases. However, as background checks are only required for gun sales through licensed firearm dealers, the number of background checks as a proxy for new gun ownership does not account for gun sales through other dealers. Additionally, the correlation between background checks and firearm injuries at the national level provides limited information. This relationship is likely more nuanced and further research taking regional differences into account is needed to advance knowledge and guide national and local priorities. Furthermore, additional covariates that may have changed appreciably in the periods just prior to and during COVID were not easily accessible in the GVA database. However, the variations presented here are major, and to substantially mitigate these results, potential confounders would not only have to have a very strong association but would have also had to change in parallel with the onset of COVID. Finally, our study only demonstrates a correlation between firearm acquisitions and firearm injuries involving children and does not indicate causality.

**Conclusion:**

During the first six months of the COVID-19 pandemic, we demonstrate a surge in fatal and nonfatal gun injuries in young children and in those inflicted by young children who discharged
a firearm. These increased rates of injury were associated with a concurrent rise in firearm acquisitions. There is an urgent need for enactment of both interventions in the local health care setting and state and federal level legislation aimed at preventing firearm injuries and deaths involving children during the COVID-19 pandemic.

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Table 1: Fatal and Non-Fatal Firearm Injuries Involving Children in March through August Prior to and During COVID-19 Pandemic

<table>
<thead>
<tr>
<th>Incidents</th>
<th>Pre-COVID Study Period</th>
<th>COVID Pandemic Study Period</th>
<th>Pre/Post COVID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2016</td>
<td>2017</td>
<td>2018</td>
</tr>
<tr>
<td>Incidents</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>130</td>
<td>155</td>
<td>134.0</td>
</tr>
<tr>
<td>Rate of Change (95% CI)</td>
<td>0.001</td>
<td>0.128</td>
<td>(-0.005, 0.007)</td>
</tr>
<tr>
<td>Non-Fatal Injuries</td>
<td>83</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>Rate of Change (95% CI)</td>
<td>0.002</td>
<td>0.093</td>
<td>(-0.003, 0.007)</td>
</tr>
<tr>
<td>Fatal Injuries</td>
<td>47</td>
<td>60</td>
<td>40.0</td>
</tr>
<tr>
<td>Rate of Change (95% CI)</td>
<td>-.001</td>
<td>0.35</td>
<td>(-0.006, 0.003)</td>
</tr>
</tbody>
</table>

*SAR = Semi-annual Rates based on 6-month study period estimates per million population
Figure 1: Rates of Firearm Injuries in (1a) and Inflicted by (1b) Children Pre- and During the COVID-19 Pandemic

Figure 1a: Rates of Firearm Injuries per million US Children Younger than 12 years of age, Pre- and During COVID

Figure 1b: Rates of Firearm Injuries per million Inflicted by US Children Younger than 12 years of age, Pre- and During COVID
Figure 2: Numbers of Background Checks (in units of 100,000) Pre- and During the COVID-19 Pandemic
Figure 3: Relationship between Rates of Firearm Injuries to (3a) and Inflicted by (3b) Children and Background Checks

Figure 3a: Relationship between Total Firearm Injuries in Children Younger than 12 Years and Number of Background Checks in units of 100,000

Figure 3b: Relationship between Total Firearm Injuries Inflicted by Children Younger than 12 Years and Number of Background Checks in units of 100,000
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