

# Pediatric injury trends and relationships with social vulnerability during the COVID-19 pandemic: A multi-institutional analysis

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<b>BACKGROUND:</b>	The impact of the COVID-19 pandemic on pediatric injury, particularly relative to a community's vulnerability, is unknown. The objective of this study was to describe the change in pediatric injury during the first 6 months of the COVID-19 pandemic compared with prior years, focusing on intentional injury relative to the social vulnerability index (SVI).
<b>METHODS:</b>	All patients younger than 18 years meeting inclusion criteria for the National Trauma Data Bank between January 1, 2016, and September 30, 2020, at nine Level I pediatric trauma centers were included. The COVID cohort (children injured in the first 6 months of the pandemic) was compared with an averaged historical cohort (corresponding dates, 2016–2019). Demographic and injury characteristics and hospital-based outcomes were compared. Multivariable logistic regression was used to estimate the adjusted odds of intentional injury associated with SVI, moderated by exposure to the pandemic. Interrupted time series analysis with autoregressive integrated moving average modeling was used to predict expected injury patterns. Volume trends and observed versus expected rates of injury were analyzed.
<b>RESULTS:</b>	There were 47,385 patients that met inclusion criteria, with 8,991 treated in 2020 and 38,394 treated in 2016 to 2019. The COVID cohort included 7,068 patients and the averaged historical cohort included 5,891 patients (SD, 472), indicating a 20% increase in pediatric injury ( $p = 0.031$ ). Penetrating injuries increased (722 [10.2%] COVID vs. 421 [8.0%] historical; $p < 0.001$ ), specifically firearm injuries (163 [2.3%] COVID vs. 105 [1.8%] historical; $p = 0.043$ ). Bicycle collisions (505 [26.3%] COVID vs. 261 [18.2%] historical; $p < 0.001$ ) and collisions on other land transportation (e.g., all-terrain vehicles) (525 [27.3%] COVID vs. 280 [19.5%] historical; $p < 0.001$ ) also increased. Overall, SVI was associated with intentional injury (odds ratio, 7.9; 95% confidence interval, 6.5–9.8), a relationship which increased during the pandemic.
<b>CONCLUSION:</b>	Pediatric injury increased during the pandemic across multiple sites and states. The relationship between increased vulnerability and intentional injury increased during the pandemic. ( <i>J Trauma Acute Care Surg.</i> 2023;94: 133–140. Copyright © 2022 Wolters Kluwer Health, Inc. All rights reserved.)
<b>LEVEL OF EVIDENCE:</b>	Prognostic and Epidemiological; Level III.
<b>KEY WORDS:</b>	Pediatric injury; COVID-19; social vulnerability; intentional injury; time series.

The SARS-CoV-2 (COVID-19) pandemic impacted children and their families across the globe, leading to unparalleled changes in lifestyle. The United States declared a state of national emergency on March 13, 2020, and stay-at-home orders

were issued regionally in the subsequent weeks.<sup>1</sup> These orders changed the daily lives of children across the nation as they no longer had access to schools, parks, and local community support programs. Simultaneously, as the United States reached an

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unemployment rate of 13%, many families experienced job loss and financial hardship.<sup>2</sup>

While hospital admissions at children's hospitals for medical conditions decreased the initial weeks of the pandemic, reports of pediatric injury varied, and the vast majority have been limited to single centers, single mechanisms of injury, or to emergency department (ED) visits alone.<sup>3-9</sup> Furthermore, children are a vulnerable population and are at increased risk for poor health outcomes and violent injury when their social determinants of health are suboptimal.<sup>10-14</sup> How the COVID-19 pandemic affected pediatric trauma and the relationship between social vulnerability and intentional injury in children has not been explored.

This study aims to compare pediatric injury during the first 6 months of the pandemic to historical controls; additionally, we sought to explore the association between intentional injury and social vulnerability and how that relationship changed in the setting of the pandemic. We hypothesized the COVID pandemic would be associated with a change in both pediatric injury mechanisms and intent. Furthermore, we hypothesized that there would be an increase in the strength of association between social vulnerability and intentional injury.

## PATIENTS AND METHODS

### Study Design, Setting, and Participants

Data were merged from institutional trauma registries at nine Level I pediatric trauma centers (PTCs) participating in the Midwest Pediatric Surgery Consortium (<http://www.mwpsc.org>) for the period from January 1, 2016, to September 30, 2020. All children younger than 18 years who met the National Trauma Data Bank (NTDB) criteria were included.<sup>15</sup> Namely, these children sustained a traumatic injury within 14 days of the initial hospital encounter with at least one of the following International Classification of Disease, Tenth Revision (ICD-10) diagnosis codes documented: ICD-10-CM S00-S99, T07, T14, T20-T28, T30-T32, and T79.A1-T79.A9. To be included, the child had to be transferred and/or admitted to the hospital, or have died from their injuries.<sup>15</sup> The study was approved by each institution's institutional review board with a waiver of consent. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines were followed for this observational cohort study (Supplementary Digital Content, <http://links.lww.com/TA/C571>).

### Variables and Statistical Methods

Trends of overall pediatric injury volume and mechanism of injury were analyzed from the beginning of the study period, January 1, 2016, through the first 6 months of the pandemic, ending on September 30, 2020. The primary exposure of interest was the COVID-19 pandemic. Patients were assigned to the "COVID cohort" if they were injured after the start date of stay-at-home orders (or safer-at-home orders) associated with each site's region, as this was when the daily life of children began to change. The COVID cohort was compared with a historical cohort. To account for the possibility of outlying data from a single year, the historical cohort was averaged across years 2016 to 2019, using data from corresponding dates of the COVID cohort. A sensitivity analysis was completed comparing the COVID cohort to a 2019 cohort alone to evaluate the change between the exposed cohort to the nearest year prior, thus minimizing the effect

of temporal changes (e.g., triage patterns, population changes, etc.) and is provided in eTables 1 and 2, <http://links.lww.com/TA/C572>. Demographic, injury characteristics, and outcomes were compared between cohorts. Injury type, mechanism, and intent were defined by the primary ICD-10 External Cause of Injury codes (E-codes). Outcomes included mortality, hospital disposition, intensive care unit (ICU) and hospital length of stay (LOS), and days on mechanical ventilation.

The relationship between the pandemic and intentional injury based on a child's "vulnerability," as described by their geocoded social vulnerability index (SVI), was explored. The Agency for Toxic Substances and Disease Registry's Geospatial Research, Analysis & Services Program created the Centers for Disease Control and Prevention SVI, a metric that reflects the degree to which a community exhibits certain social conditions that may weaken their ability to prevent human suffering during times of external stress.<sup>16</sup> The SVI ranks each census tract on 15 social factors compromising four subthemes: socioeconomic status, household composition and disability, minority status and language, and housing and transportation. The SVI tract rankings are based on percentiles and range from 0 to 1, with 1 indicating greatest vulnerability. Because SVI is assigned at the census tract level, a weighted value for zip code areas was created based on the relative proportion of residential addresses in the census tracts intercepting with each zip code.<sup>12</sup> We investigated the association between SVI and its subthemes and intentional injury, as compared with unintentional injury, and the impact of the pandemic on these associations.

Raw and cumulative numbers of pediatric injuries averaged by month were presented. Day to day variation data were displayed with LOESS smoothing techniques. A two-sample Komogorov-Smirnov test comparing the two cohorts was performed. In addition, interrupted time series analysis with autoregressive integrated moving average modeling was used to estimate the expected pediatric injury during the pandemic while controlling for temporal variation.<sup>17</sup> This was graphed against the observed trauma volume during the first 6 months of the pandemic, and a two-sample Kolmogorov-Smirnov test was used to test significance. For the time series analyses, an averaged date of March 23, 2020, was used as there was slight variation in Stay at Home and Safer at Home initiation dates between sites.

Descriptive statistics are presented for each cohort. Data were missing for key variables in less than 5% of cases, and are presented if missingness accounts for 5% or more of the variable. Pearson  $\chi^2$  was used to compare categorical variables, and when significant a comparison of binomial proportions was utilized when more than two groups were present and then provided in the text. Student's *t* test and Wilcoxon rank-sum were used to compare mean values for normally distributed continuous variables and median values for non-parametric continuous variables, respectively. Fisher's exact tests were used if any category had less than 5 observations. Two-tailed significance was set at *p* less than 0.05.

To explore the relationship between the pandemic period and intentional injury (dichotomized and compared with unintentional injury), univariate logistic regression and multivariable logistic regression while controlling for clustering by hospital site were completed. To understand if the relationship between SVI and intentional injury was moderated by the pandemic,

the COVID period and SVI was used as an interaction term. All analyses were performed using R statistical software (RStudio, version 1.4.1717 2009–2021 RStudio, PBC).<sup>18–24</sup>

## RESULTS

### Participants

Overall, 47,385 patients met inclusion criteria, 8,991 treated in 2020 and 38,394 treated in 2016 to 2019. The COVID cohort, limited to the pandemic period, included 7,068 patients. The averaged historical cohort for the matched time frame from years 2016 to 2019 included 5,891 (SD, 472) patients. There was a 20% increase in pediatric injury during the COVID cohort as compared with the historical cohort (Fig. 1,  $p = 0.031$ ). Similar findings were appreciated in the sensitivity analysis of 2019 (eFig. 1, <http://links.lww.com/TA/C572>). Despite day-to-day variation, the average number of injured children treated per day increased from 31 to 37, also an increase of approximately 20% (eFig. 2, <http://links.lww.com/TA/C572>). Accounting for seasonal and yearly variation in the interrupted time series analysis, the number of observed injuries were significantly greater than the expected injuries during the first 6 months of the pandemic ( $p < 0.001$ , Fig. 2).

### Descriptive Data, Outcome Data, and Main Results

Demographic and injury characteristics are presented in Table 1. There was a small increase in the proportion of children 10 years to 14 years of age (26.8% COVID cohort vs. 24.3% historical cohort,  $p = 0.002$ ), with a corresponding decrease in injured children younger than 1 year (8.7% COVID cohort vs. 9.8% historical cohort,  $p = 0.036$ ). Socioeconomic status as represented by US zip code-based median household income quintiles saw an increase in the proportion of injured children in the 5th quintile, representing the highest income (25.2% COVID cohort vs. 23.3% historical cohort,  $p = 0.009$ ). Similarly, there was

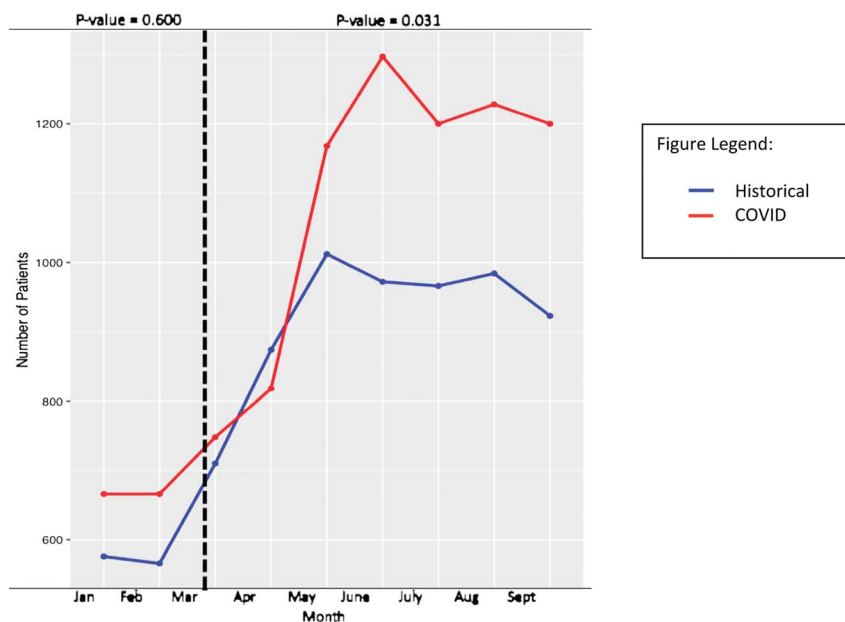
a decrease in the weighted mean of overall SVI and SVI sub-themes in the COVID cohort, indicating slightly *less* vulnerability compared with historical controls (Table 1). Subthemes for socioeconomic status and housing/transportation met statistical significance (Table 1).

While many injury types and mechanisms increased (eFig. 3, <http://links.lww.com/TA/C572>), there was a statistically significant increase in relative proportion of penetrating injuries (10.2% COVID cohort vs. 8.0% historical cohort,  $p < 0.001$ ) and burn injuries (6.7% COVID cohort vs. 5.3% historical cohort,  $p = 0.001$ ), with a commensurate decrease in the proportion of blunt injuries. Notably, firearm injuries increased (2.3% COVID cohort vs. 1.8% historical cohort,  $p = 0.043$ ), while falls (37.5% COVID cohort vs. 42% historical cohort,  $p < 0.001$ ), occupant motor vehicle collisions (MVCs) (26.3% COVID cohort vs. 34.5% historical cohort,  $p < 0.001$ ), and car versus pedestrian collisions (3.9% COVID cohort vs. 8.0% historical cohort,  $p < 0.001$ ) decreased. Bicycle collisions and collisions involving other land transportation vehicles (e.g., all-terrain vehicles [ATV]) increased (Table 1). While statistically significant, the relative proportions of injury intent did not change in a clinically meaningful way.

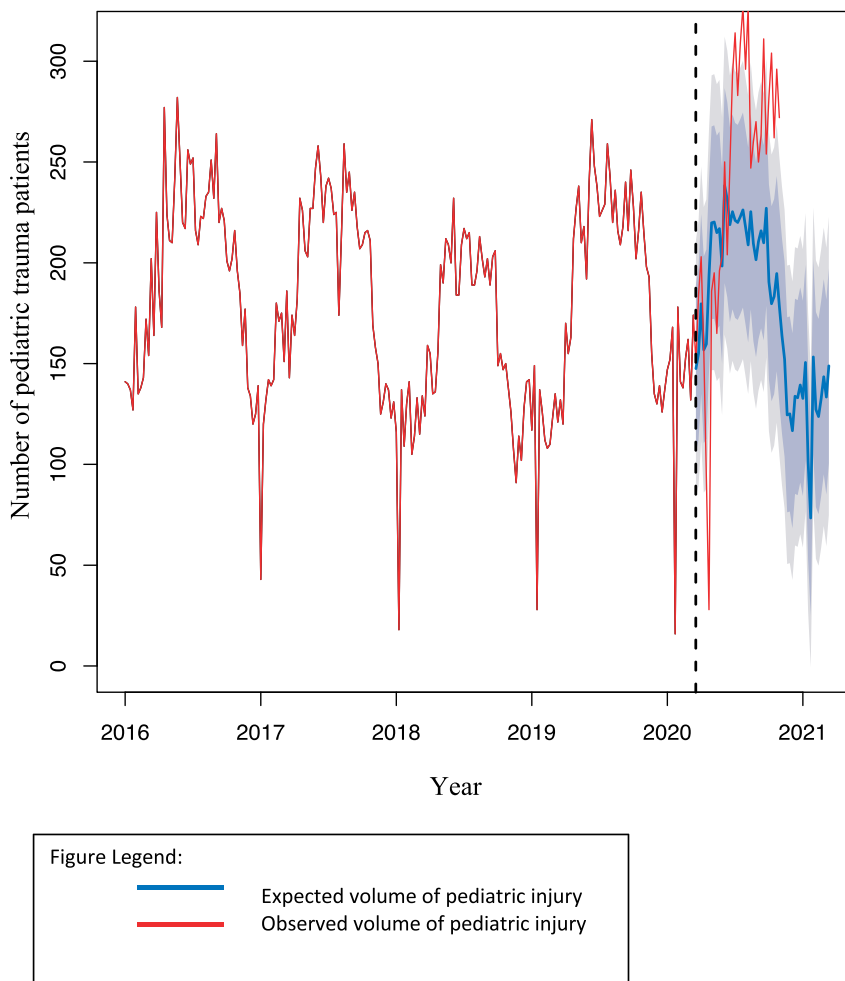
Among the outcomes studied (Table 2), there were changes in disposition from the ED, with a greater proportion of children discharged home in the COVID cohort (22.8% vs. 13.4% historical,  $p < 0.001$ ). In addition, fewer went to the operating room in the COVID cohort (9.1% vs. 12.2% historical,  $p < 0.001$ ). There were no significant changes in median ICU LOS, hospital LOS, or mechanical ventilation days.

### Social Vulnerability and Intentional Injury

In univariate analyses, the COVID cohort was not associated with intentional injury. Race, ethnicity, age, median household income, and SVI were associated with intentional injury (Table 3). In the adjusted model, ethnicity was not included



**Figure 1.** Number of pediatric injuries per month comparing COVID cohort (red) vs. the averaged 2016 to 2019 historical cohort (blue), with dashed line representing the beginning of the COVID period.



**Figure 2.** Interrupted time series analysis estimating expected number of pediatric injuries per week (blue), compared with observed number of pediatric injuries per week (red) from January 1, 2016, to September 30, 2020.

due to the high proportion of missingness and median household income was not included due to moderate collinearity with SVI (correlation coefficient =  $-0.84$ ). Sex was included for face validity, and the COVID cohort was included to test the study aims. In adjusted models, the COVID cohort alone was not associated with intentional injury; however, the interaction between SVI and the COVID cohort was statistically significant ( $p = 0.017$ ). Stratified analyses demonstrated the association between SVI and intentional injury increased during the pandemic across all SVI subthemes compared with the historical cohort (Fig. 3 and eFigure 4, <http://links.lww.com/TA/C572>).

## DISCUSSION

In this multi-institutional study, an overall increase in pediatric injury was observed during the first 6 months of the pandemic as compared with historical controls. This affected children of all demographics and socioeconomic backgrounds, including children from higher income and overall less vulnerable zip codes. The mechanisms of injury changed during this period, with an increase in firearms, burns, bicycle collisions, and ATV-related injuries. Finally, higher SVI, indicating

greater vulnerability, was associated with intentional injury, and this relationship was exacerbated during the pandemic.

The higher overall rate of injuries we identified differs from a number of reports in the published literature. While we saw an overall increase in trauma encounters starting as early as April 2020, Sanford and colleagues' retrospective review of trauma registry data at a single US-based Level I PTC between March 15 and May 15 saw a decline of about 16% in the 8 weeks following the US Emergency Declaration.<sup>7</sup> Likewise, a 22% decrease in overall pediatric trauma early in the pandemic was found in an evaluation of pediatric trauma admissions 4 weeks after the pandemic began at a single center in Ireland and a 34% decrease in pediatric ED trauma encounters was identified in the first 6 weeks of the pandemic at another single PTC in the United States.<sup>3,8</sup> A multi-institutional trauma registry study through June 30, 2020, also reported a decrease in trauma volumes.<sup>25</sup> Pediatric Health Information Systems-based studies have demonstrated that both ED visits (through August 2020) and hospital admissions (through June 2020) for pediatric injury declined in 2020 compared with prior years and expected volumes.<sup>6,26</sup> The differences in pediatric trauma volume between our study and that appreciated by the other studies described is



**TABLE 1.** Demographic and Injury Characteristics of the Patient Population by Cohort, n (%)

	Historical Average 2016–2019, n = 5,891	COVID 2020, n = 7,068	p
Male	3,639 (61.8)	4,289 (60.7)	0.198
Age, y			0.005
< 1	579 (9.8)	618 (8.7)	
1–4	1,232 (20.9)	1,513 (21.4)	
5–9	1,842 (31.3)	2,155 (30.5)	
10–14	1,434 (24.3)	1,891 (26.8)	
15–17	804 (13.7)	891 (12.6)	
Race			0.630
White	4,349 (75.7)	5,222 (76.2)	
African American	1,033 (18.0)	1,199 (17.5)	
Asian	86 (1.5)	105 (1.5)	
Hawaiian/PI	10 (0.2)	8 (0.1)	
American Indian	14 (0.2)	27 (0.4)	
Other	250 (4.4)	294 (4.3)	
Ethnicity			<0.001
Hispanic	368 (6.3)	478 (6.8)	
Non-Hispanic	4,744 (80.5)	6,384 (90.3)	
Unknown/missing	778 (13.2)	206 (2.9)	
Median household income			0.034
Quintile 1 (poorest)	1,148 (19.6)	1,291 (18.3)	
Quintile 2	1,180 (20.1)	1,344 (19.1)	
Quintile 3	1,040 (17.7)	1,295 (18.4)	
Quintile 4	1,135 (19.4)	1,337 (19.0)	
Quintile 5 (richest)	1,364 (23.3)	1,778 (25.2)	
Weighted SVI, SD	0.4640 (0.2213)	0.4559 (0.2236)	0.007
SES	0.4926 (0.2377)	0.4824 (0.2411)	0.002
Household/disability	0.5867 (0.2093)	0.5825 (0.2079)	0.133
Minority/language	0.3212 (0.2153)	0.3179 (0.2138)	0.262
Housing/transportation	0.4659 (0.1805)	0.4608 (0.1856)	0.037
Injury type*			<0.001
Blunt	4,731 (80.5)	5,568 (78.8)	
Penetrating	475 (8.2)	776 (11.0)	
Burn	317 (5.3)	475 (6.7)	
Unspecified	122 (1.7)	134 (1.9)	
Not applicable	246 (3.4)	115 (1.6)	
Injury mechanism*			<0.001
Fall	2,482 (42.2)	2,652 (37.6)	
MVC	1,437 (24.5)	1,923 (27.3)	
Nontraffic	124 (8.6)	131 (6.8)	
Motorcycle	22 (1.5)	36 (1.9)	
MVC occupant	496 (34.5)	505 (26.3)	
MVC other	5 (0.4)	5 (0.3)	
MVC with cyclist	64 (4.5)	69 (3.6)	
MVC with pedestrian	115 (8.0)	75 (3.9)	
MVC unspecified	24 (1.7)	12 (0.6)	
Bicycle collision	261 (18.2)	505 (26.3)	
Pedestrian (including skateboarding, rollerblading)	46 (3.2)	60 (3.1)	
Land transportation (including ATV collisions)	280 (19.5)	525 (27.3)	

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**TABLE 1.** (Continued)

Struck by/against	534 (9.1)	494 (7.0)	
Firearm	108 (1.8)	215 (3.1)	
Cut/pierce	182 (3.1)	251 (3.6)	
Drown/submerge	22 (0.4)	28 (0.4)	
Burn	316 (5.4)	475 (6.7)	
Abuse	228 (3.9)	264 (3.8)	
Bites/stings	186 (3.2)	318 (4.5)	
Natural	78 (1.3)	64 (0.9)	
Other/not specified	237 (4.0)	354 (5.0)	
Intent of injury*			<0.001
Unintentional	5,374 (92.3)	6,508 (92.1)	
Intentional, assault	378 (6.5)	459 (6.5)	
Intentional, suicide	37 (0.6)	44 (0.6)	
Intentional, other	35 (0.6)	49 (0.7)	
Unknown	1 (0.0)	1 (0.0)	
ISS			0.888
0–15	5,132 (92.4)	6,490 (92.2)	
16–24	262 (4.7)	336 (4.8)	
≥25	158 (2.9)	210 (3.0)	

\*Primary external cause of injury code included only.

ISS, Injury Severity Score; PI, Pacific Islander; SES, socioeconomic status.

likely due to differences in time frame of the data captured. Our data identified a rise in pediatric trauma volume beginning as early as April 2020; however, more demonstrable differences were observed between May and September.

Our study demonstrated differences in the type, mechanism, and intent of injury during the first 6 months of the pandemic. We found an increase in injuries related to firearms, burns, and collisions involving bicycles and other forms of land transport like ATVs, with a decrease in the relative proportion of falls, MVCs, and other blunt injury compared with historical controls. These trends were similar to those identified by Sanford and colleagues<sup>17</sup> evaluation of a single institution's trauma registry, which identified a relative increase in penetrating trauma encounters and burn admissions, with a corresponding decline in blunt injuries. While the relative decrease in blunt injuries in our study was modest, the change in mechanisms most often associated with blunt injury were more pronounced.

For example, MVC occupant injuries decreased from 34.5% to 26.3%, while injuries from bicycle collisions increased from 18.3% to 26.3%. Concordant with our findings, Matthay et al.<sup>27</sup> in a single institution study that captured both adult and pediatric injury, found a 71% decrease in pedestrian versus auto injuries and a 27% decrease in MVCs. Sanford et al. also found a decrease in MVCs while, akin to our findings, injuries due to ATV, bicycle, and skateboard collisions almost doubled.<sup>7</sup> Findings from the National Electronic Injury Surveillance System data between March and September 2020 reported increases in injuries related to skateboards and scooters, ATVs and mopeds, and batteries, and decreases in sport-related injuries compared with 2019. We also saw a decrease in falls and struck by/against injuries, presumably related to fewer sports-related injuries and fewer injuries on playgrounds and schoolyards. On the other hand, fewer families were on the road, either for day to day activities or for travel, which may explain the decline in MVCs.

**TABLE 2.** Outcomes After Injury by Cohort, n (%)

	Historical Average 2016–2019, n = 5,891	COVID 2020, n = 7,068	p
Overall mortality	57 (1.0)	67 (0.9)	0.732
ED disposition*			
Admit floor	3426 (58.2)	3501 (49.5)	<0.001
Admit ICU	436 (7.4)	425 (6.0)	
Admit operating room	720 (12.2)	642 (9.1)	
Discharged home	790 (13.4)	1612 (22.8)	
Transferred out	16 (0.2)	14 (0.2)	
Other (including AMA, jail, etc.)	4 (0.1)	10 (0.1)	
Died in the ED	17 (0.3)	23 (0.3)	
Unknown/missing	482 (8.2)	841 (11.9)	
Hospital disposition			
Home without services	4287 (84.7)	4405 (81.4)	<0.001
Home with services	47 (0.9)	10 (0.2)	
Rehab, SNF, LTC	50 (1.0)	66 (1.2)	
Transferred out	103 (2.0)	107 (2.0)	
Other (jail, AMA)	11 (0.2)	8 (0.2)	
Died inpatient	40 (0.8)	44 (0.8)	
Unknown/missing	526 (10.4)	769 (14.2)	
Median vent days (IQR)	3 (0.5–5.5)	3 (0.5–5.5)	0.660
Median LOS, ICU (IQR)	2 (0.5–3.5)	2 (0–4)	0.270
Median LOS, hospital (IQR)	1 (0–2)	1 (0–2)	0.200

\*If ED disposition and hospital disposition were incongruent (e.g., ED disposition indicated as home, however, hospital disposition also home, rather than “not applicable” because the child was not admitted), then LOS was used to determine admission status and the discordant variables were considered “unknown” (see category).

AMA, against medical advice; wo, without; Rehab, rehabilitation; SNF, skilled nursing facility; LTC, long-term care facility; IQR, interquartile range.

Our data identified a notable increase in pediatric firearm injuries, which almost doubled in the 6 months following the onset of the pandemic, compared with the historical average and compared with 2019 alone during the same period. While Matthey and colleagues<sup>27</sup> found a consistent volume of violent-related traumatic injuries, they did find a trend toward increased gunshot wounds early in the pandemic ( $p = 0.10$ ).<sup>27</sup> Cohen et al.'s<sup>28</sup> study using the Gun Violence Archive, found an increase in firearm injuries in children younger than 12 years (relative risk, 1.90; 95% confidence interval, 1.58–2.29) during the first 6 months of the pandemic, when compared with an averaged historical cohort similar to our study (2016–2019). While Sanford et al. did not identify an increase in firearms, the study period was limited to only the first 8 weeks of the pandemic, which may explain the discordant findings. While we did not see an increase in the relative proportion of children with an E-Code related to non-accidental trauma, it is important to note there was concern related to the welfare of children in this context and is thus explored in depth elsewhere.<sup>29</sup> All together, these findings highlight the differential effect the COVID pandemic as a whole on injury patterns in children.

We found that injury increased in a similar fashion across sex and race, and with a slight decrease in proportion infants and an increase in the 10- to 14-year-old age group. Sanford et al. found no difference in sex or in median age, and a slight increase in proportion of children identifying as White race. Differences in findings are likely related to the longer timeframe and multi-institutional nature of our study. It is possible our finding

that more 10-year to 14-year-old children were injured in the COVID cohort compared with the historical cohort may reflect a lack of structure or supervision normally provided by in-person attendance at school.

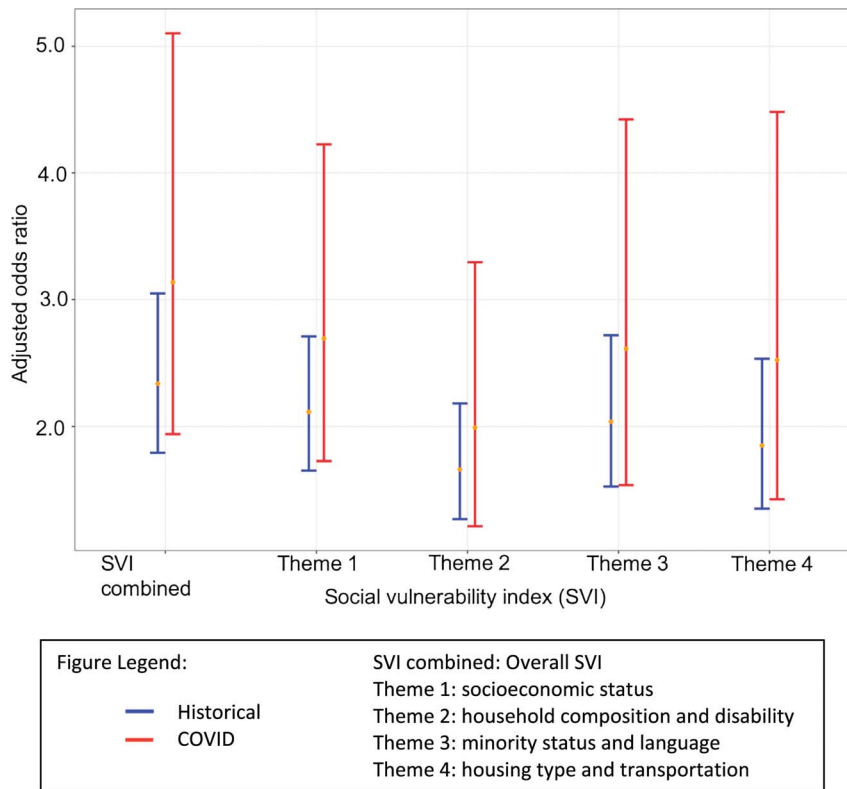
Interestingly, we appreciated an increase in injuries during COVID across all income quintiles; however, the most profound change, of just over 30%, was in the “richest” quintile. This is concordant with change in weighted SVI between the two cohorts. Overall, across the combined SVI and all the SVI sub-themes, the weighted values were slightly lower in the COVID cohort as compared with the historical cohort, reflecting slightly less vulnerability overall. There are similar findings in the sensitivity analysis comparing the COVID cohort to 2019 alone, meaning the change is not simply a time-based improvement in socioeconomic status. These data indicate the COVID pandemic was associated with increased pediatric injury across all strata of society.

However, children who lived in zip codes with increased social vulnerability had increased odds of intentional injury compared with unintentional injury. This relationship was

**TABLE 3.** Association of the COVID Pandemic and Intentional Injury, Univariate and Multivariable Models Controlling for Demographic Factors and for Clustering by Site

	OR (95% CI)	aOR (95% CI)
Cohort		
Historical average	Reference	Reference
COVID	1.0 (0.9–1.1)	1.1 (0.9–1.1)
Sex		
Female	Reference	Reference
Male	1.1 (1.0–1.2)	1.0 (0.9–1.1)
Age, y		
<1	19.0 (16.1–22.6)	17.8 (15.0–21.3)
1–4	3.5 (2.9–4.2)	3.2 (2.7–3.9)
5–9	Reference	Reference
10–14	2.3 (1.9–2.8)	2.2 (1.8–2.6)
15–17	7.4 (6.2–8.9)	6.5 (5.4–7.9)
Race		
White	Reference	Reference
African American	4.0 (3.6–4.4)	3.2 (2.9–3.6)
American Indian	2.4 (1.1–4.5)	2.5 (1.1–5.1)
Hawaiian/PI	0.9 (0.1–2.9)	1.3 (0.2–3.9)
Asian	1.0 (0.6–1.5)	0.9 (0.6–1.5)
Other	1.4 (1.1–1.7)	1.2 (0.9–1.5)
Ethnicity		
Non-Hispanic	Reference	—
Hispanic	1.0 (0.8–1.5)	—
Unknown/missing	1.3 (1.2–1.5)	—
Median household income		
Quintile 1 (poorest)	Reference	—
Quintile 2	0.7 (0.6–0.7)	—
Quintile 3	0.4 (0.4–0.5)	—
Quintile 4	0.4 (0.4–0.5)	—
Quintile 5 (richest)	0.3 (0.2–0.3)	—
Weighted SVI	7.9 (6.5–9.8)	2.5 (2.0–3.2)

95% CI, 95% confidence interval; Pacific Islander, PI; adjusted odds ratio, aOR; SVI, social vulnerability index.



**Figure 3.** Adjusted odds of intentional injury as compared with unintentional injury in the COVID (red) and historical cohorts (blue) by combined SVI and by individual SVI subthemes.

identified at baseline, and then was found to be exacerbated during the pandemic. All SVI domains (socioeconomic status, household composition and disability, minority status and language, and housing and transportation) reflected this relative increase in association with intentional injury in children during the pandemic. In unadjusted analyses, this was most pronounced for minority children and children who speak English “less well,” as compared with those with increased vulnerability related to socioeconomic status, household composition, or housing type and transportation. Hence, the SVI metric, which was created to identify communities with less “ability to prevent human suffering during times of external stress” appropriately identified children with a disproportionately increased risk for intentional injury during the pandemic. Exploration into these relationships is essential to further inform social service allocation during times of external stress, such as the COVID pandemic.

Our findings have several important limitations. First, the data are from institutional trauma registries, which do not capture all injuries that are treated at the hospital, including non-transferred ED discharged patients. Children dying before arrival or not treated at the trauma centers included in this study were not captured. While each Level I PTC in this study has a geographically large catchment area, this is not an epidemiologic study and thus population estimates cannot be made. Normalizing to population estimates was explored however census-based estimates for 2020 were not available. Likewise, a change in transfer patterns from adult centers to pediatric centers may explain a degree of the increased volume captured, as adult centers

had increased need to treat COVID-positive adult patients. Social vulnerability index is a metric created by census tract, and use by zip code loses granularity and introduces risk for misclassification. Social vulnerability index uses 15 social factors from the 5-year American Community Survey data, which is released every 2 years by the US Census Bureau in December of the year following the Survey. While we used the most up-to-date SVI from 2018, reflecting the 2014 to 2018 survey data, there is risk in attributing the same SVI to the COVID cohort and the historical cohort, since SVI (and also median income) may have changed in the interim. We suspect any changes would lead to conservative estimates because vulnerability indices may have increased during the pandemic, indicating an even stronger relationship with intentional injury than we identified. We were also limited by the lack of a non-injured population, thus limiting analyses.

There were concurrent social unrest and potentially related tensions during the study period worth mentioning. Throughout the midwest, and much of the nation, there were protests related to high-profile police shootings. Some were peaceful and some involved looting and/or violence. It is impossible within the context of these data to parse out a causal relationship between the pandemic and pediatric injury compared with social unrest and pediatric injury. There are likely unmeasured confounders that may have disproportionately affected certain neighborhoods. For example, changes in disposable income may have affected children in lower income households more than higher income households. Changes in police presence, local isolation policies, regional healthcare and childcare programing, and relief payments to

families and local businesses may have impacted different neighborhoods in different ways.

## CONCLUSION

This study identified an increase in pediatric injuries associated with the COVID pandemic treated at Level I PTCs and examined the changes in the types of injuries seen across multiple sites and states. Importantly, we identified that the SVI was associated with intentional injury in children and that the relationship between increased vulnerability and intentional injury was even stronger during the pandemic, highlighting children most at risk of intentional injury during times of external stress. Collectively, these data suggest a child's social determinants of health, including the neighborhood in which they live, may be related to different injury patterns during the pandemic. These findings are critical to inform and guide resource allocation and tailored injury prevention methodologies for all children and families during times of family, community, and national stress.

## AUTHORSHIP

K.T.F., A.T.C., M.F., M.E.F., P.C.M., K.E.S., K.V.A., and T.T.S. made substantial contributions to research design and idea development, data collection and analysis, data interpretation, article writing, and critical revisions. K.J.D., R.A.F., D.S.F., J.D.F., S.G., M.S.K., M.K., M.P.L., C.M.L., T.A.M., N.R., and S.D.S.P. made substantial contributions to data collection and analysis and article editing, including critical revisions. All authors give final approval of the enclosed article.

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## DISCLOSURE

The authors declared no conflicts of interest.

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