Epidemiology of pediatric trauma during the COVID-19 pandemic shelter in place

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ABSTRACT

INTRODUCTION: The first COVID-19 cases occurred in the US in January of 2020, leading to the implementation of shelter in place. This study seeks to define the impact of shelter in place on the epidemiology of pediatric trauma.

METHODS: We examined pediatric trauma admissions at 5 Level 1 and 1 Level 2 US pediatric trauma centers between January 1 and June 30, 2017–2020. Demographic and injury data were compared between pre- and post–shelter in place patient cohorts.

RESULTS: A total of 8772 pediatric trauma activations were reviewed. There was a 13% decrease in trauma volume in 2020, with a nadir at 16 days following implementation of shelter in place. Injury severity scores were higher in the post–shelter in place cohort. The incidence of nonmotorized vehicle accidents and gunshot wounds increased in the post–shelter in place cohort.

CONCLUSION: We found an overall decrease in pediatric trauma volume following shelter in place. However, injuries tended to be more severe. Our findings help inform targeted injury prevention campaigns during future pandemics.

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and the Centers for Disease Control and Prevention (CDC) noted a 70% decrease in emergency department visits for patients ≤14 years of age during the same time period [4]. Single-center retrospective reviews during this time period have shown similar declines in the rate of adult trauma [5,6] despite increased injury severity [6]. Although reports are sparse, similar trends have also been noted in pediatric orthopedic trauma in the United States [7] and abroad [8,9].

In addition to changes in trauma volume, many experts anticipated differences in the etiology of pediatric trauma following the implementation of SIP. Increased stress associated with the pandemic, strained relationships, and social isolation were postulated to contribute to an increase in domestic violence including nonaccidental trauma (NAT) in children [10,11]. These risk factors were compounded by the fact that vulnerable children were isolated from the limited resources they had, including schools and community centers [12]. Additionally, the rate of firearms sales increased substantially with the onset of the pandemic [13], creating additional risk factors for accidental and nonaccidental traumatic incidents. Early reports show an increase in gun-related trauma in adults following the implementation of SIP [14]. With this in mind, we sought to characterize the impact of COVID-19 SIP orders on pediatric trauma during the early months of the pandemic. Based on previous trends, we hypothesized that overall trauma volume would decrease but expected to see a higher volume of domestic violence, gun violence, and NAT.

METHODS

Pediatric trauma admissions from 5 Level 1 and 1 Level 2 pediatric trauma centers (Table 1) in 4 US states (California, Utah, Colorado, and Florida) were reviewed. Patients ≤18 years old who met trauma registry criteria from January 1 to June 30, 2017–2020, were compiled by each institution. Data were deidentified and pooled for analysis relative to their county’s SIP order.

Demographic and injury data from patients injured in 2020 before (pre-SIP cohort) and after SIP (post-SIP cohort) were compared to date-matched controls (controls) from 2017 to 2019. Supplemental file 1 describes the variables examined. The Wilcoxon rank-sum test was used to compare numerical variables, and the Fisher exact test was used to compare incidence and volume distribution between years. Bonferroni corrections were applied where multiple comparisons were made. Analysis was performed using R version 4.0.0 (R Foundation for Statistical Computing, Vienna, Austria). IRB approval was obtained from each center.

RESULTS

A total of 1972 trauma activations occurred in 2020, 2277 in 2017, 2244 in 2018, and 2279 in 2019, representing an approximately 13% reduction in trauma volume. Figure 1 shows decreased cumulative trauma volumes across all centers starting approximately 20 days prior to SIP compared to historical controls. The 30 days surrounding SIP (7 days before through 22 days after) saw the greatest change in volumes across all centers (P < .001). Daily mean trauma volume 16 days after SIP saw the greatest decline at a 59.9% decrease from the historical average (5.7 vs 14.2 patients). Figure 2 shows differences in trauma volumes by state. Shaded boxes highlight the 30-day window with the most significant change in trauma volumes. In California (9 days pre-SIP to 20 days post-SIP) and Colorado (11 days pre-SIP to 18 days post-SIP), this window occurred around the implementation, whereas it did not occur until much later in Florida (41 days post-SIP to 70 days post-SIP). Trauma volumes in Utah did not decrease significantly (P = .085).

Race, ethnicity, age, sex, arrival time (Table 2), insurance type, median income by zip code, and day of the week (data not shown) did not differ between the pre-SIP cohort and controls when examined across all centers. Following SIP, trauma volume decreased between 8:00 and 15:00 and increased between 18:00 and 22:00. This change appears to be driven by the Colorado cohort (Supplemental Table 2). Other demographic data did not vary when examined across all centers (Table 2). When demographic data were examined by state (Supplemental Table 2), the proportion of patients covered by government insurance programs increased in California (48.7% vs 39.7%, P = .027) in the post-SIP cohort compared to controls. Florida saw significantly more Hispanic patients (60.9% vs 49.9%, P = .008) in the post-SIP cohort compared to controls. Finally, age increased in the Colorado cohort (7 [4, 12] years old vs 6 [3, 11] years old, P = .012) and decreased in the Florida cohort (6 [3, 14] vs 9 [4, 15], P = .006) in the post-SIP cohort compared to controls.

Mechanism of injury did not differ between the pre-SIP cohort and controls (overall P = .051). Following SIP, the incidence of nonmotorized vehicle accidents (15.0% vs 8.9%, P < .001) and gunshot wounds (3.3% vs 1.8%, P = .002) increased compared to controls across all centers (Table 3). There was a significant change in the admitting service...
for trauma patients post-SIP compared to age-matched controls (overall

\( P = .026 \), which may further illustrate changes in the mechanism and
type of injuries suffered by patients post-SIP. Specifically, the number
of admissions to facial surgery services decreased (13.1% in 2017–
2019 cohort vs 10.6% in 2020 cohort, \( P = .03 \)) (Fig 2).

Acuity of injury (injury severity score [ISS]), need for ICU admission,
and ICU length of stay (LOS) between the pre-SIP cohort and controls
did not differ. Following SIP, median ISSs were higher compared to con-
trols (5 [4, 10] vs 4 [3, 9]; \( P < .01 \)) (Table 2). The percentage of patients
with severe injuries (ISS \( \geq 25 \)) [15] increased during SIP (5.8% vs 3.5%
pre-SIP, \( P = .019 \)). This trend was not present during control years
(4.6% April–June vs 5.1% January–March; \( P = .30 \)). Likelihood of ICU ad-
mission did not differ, but median ICU LOS was higher in post-SIP pa-
tients compared to controls (Table 2). Pediatric trauma mortality
following SIP did not differ compared to controls (1.3% vs 1.2%, \( P = .76 \)).

**DISCUSSION**

This study examines the impact of the COVID-19 pandemic on the
epidemiology of pediatric trauma across 6 centers in 4 states and is
one of the largest studies of pediatric trauma etiology during this period.
We noted a significant decrease in the incidence of pediatric trauma im-
imediately following the implementation of SIP. Although data regarding
the incidence of nonorthopedic pediatric trauma in the early phase of
the COVID–19 pandemic is sparse, these findings correlate with findings
in the adult trauma population [5,16,17]. Work by Bram and colleagues
on pediatric fractures also noted over a 2-fold decrease in fracture vol-
ume during the pandemic. Additionally, they found an increased rate
of bicycle injuries during lockdown compared to controls, similar to
our findings [7]. Proposed reasons for this change include a shift from
organized sports or playground activities toward an increase in children
spending time doing more “pandemic-appropriate” activities, including
playing at home and outdoors in their neighborhoods.

Patients who did present to the hospital had higher ISS, more severe
injuries, and longer ICU stays, suggesting that those who sought care
suffered more significant trauma, a phenomenon noted in another
work [6]. We also noted a shift in the mechanisms responsible for
trauma activations during the lockdown. Penetrating trauma, and gun-
shot wounds in particular, increased in the post-SIP cohort. There was a
nearly 2-fold increase in the incidence of penetrating trauma. These
findings corroborate work by Abdallah et al [14] and are concerning
given the increasing prevalence of firearms in homes [13]. Similarly,
a commentary out of Philadelphia by Hatchmonji and colleagues de-
scribed an increase in firearm violence across their community early
in the lockdown [18]. Reasons proposed by the group included the in-
crease in firearm sales as we noted previously, as well as a potential in-
creased risk of community violence due to the stay-at-home orders in
disadvantaged neighborhoods [18].

Despite widely held concerns that SIP would increase the incidence
of domestic violence and child abuse, our work did not find a signifi-
cance difference in the incidence of NAT between the pre-SIP and
post-SIP cohorts. This was unanticipated and is in contrast to work by
Kovler et al [19] that revealed a 2-fold increase in NAT at a single
Level 1 pediatric trauma center. However, work from the UK and
Ireland has had similar findings to ours, with no observable increase
in NAT [9,20]. Nevertheless, close observations of trends in NAT remain
imperative, as increasing pressure in the home from prolonged lock-
downs may ultimately drive rates up as the pandemic continues.

The major weakness of the study is its retrospective nature. How-
ever, data were collected using prospectively maintained trauma regis-
tries. The goal of this study was to examine the specific effect of SIP on
pediatric trauma trends. Further studies examining a longer time period
may provide additional insight into the effect of a pandemic on pediatric
injuries. Strengths include a large, geographically and socioeconomically
diverse patient population.

Our study found that although overall trauma volume decreased
around SIP, the nature of traumatic injuries tended to be more severe

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**Fig 2.** Daily trauma volume by state for 6 pediatric trauma centers across the US from January to June, 2017–2020. Dates on the horizontal axis were normalized relative to the shelter-in-place order for each center's county; trauma volume was plotted using a 7-day running average. The shaded areas mark the 30-day periods which saw the most significant change in pediatric trauma volume for each state. \( P \) value was calculated using Fisher exact test to compare volume in 2020 to historical controls.
after SIP. Overall, we found an increase in nonmotorized vehicle accidents (eg, bicycle accidents) and penetrating trauma (eg, firearm injury). Our findings may help inform targeted injury prevention campaigns during future surges of COVID-19. Lockdowns in vulnerable neighborhoods must be coupled with increased social support to discourage further violent injury. Education on appropriate safety measures, such as helmets and protective gear, is essential for children increasingly riding their bicycles in the neighborhood.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2021.06.001.

**Author Contribution**

Dr Bessoff and Mr. Han prepared the manuscript, contributed to study conceptualization and design, designed data collection instruments, and performed data analysis.

Dr Chao, Ms Stroud, and Ms Cho contributed to study conceptualization and design, designed the data collection instruments, performed

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### Table 2

Demographic descriptions of pre-SIP and post-SIP cohorts

|               | Pre-SIP 2017–2019 | Post-SIP 2020 | P value     | Pre-SIP 2017–2019 | Post-SIP 2020 | P value     |
|---------------|-------------------|---------------|-------------|-------------------|---------------|-------------|
|               | (N = 2758)        | (N = 882)     |             | (N = 4042)        | (N = 1090)    |             |
| Race          |                   |               |             |                   |               |             |
| Asian/Pacific Islander | 111 (4.0%) | 37 (4.2%) | .336        | 197 (4.9%) | 49 (4.5%) | .324        |
| Black         | 237 (8.6%)        | 77 (8.7%)     |             | 335 (8.3%)       | 76 (7.0%)     |             |
| Native American | 18 (0.7%)      | 6 (0.7%)      |             | 41 (1.0%)        | 5 (0.5%)      |             |
| Other         | 366 (13.3%)       | 89 (10.1%)    |             | 580 (14.3%)      | 152 (13.9%)   |             |
| White         | 1924 (69.8%)      | 597 (67.7%)   |             | 2763 (68.4%)     | 748 (68.6%)   |             |
| Missing       | 102 (3.7%)        | 76 (8.6%)     |             | 126 (3.1%)       | 60 (5.5%)     |             |
| Ethnicity     |                   |               |             |                   |               |             |
| Hispanic      | 932 (33.8%)       | 308 (34.9%)   | .234        | 1310 (32.4%)     | 363 (33.3%)   | .189        |
| Not Hispanic  | 1745 (61.3%)      | 523 (59.3%)   |             | 2619 (64.8%)     | 659 (60.5%)   |             |
| Missing       | 81 (2.9%)         | 51 (5.8%)     |             | 113 (2.8%)       | 68 (6.2%)     |             |
| Age           |                   |               |             |                   |               |             |
| Median [Q1, Q3]| 8 [3, 13]        | 9 [4, 14]     | .128        | 8 [3, 13]        | 7 [3, 13]    | .857        |
| Sex           |                   |               |             |                   |               |             |
| Female        | 995 (36.1%)       | 325 (36.8%)   | .705        | 1561 (38.6%)     | 467 (37.3%)   | .465        |
| Male          | 1763 (63.9%)      | 557 (63.2%)   |             | 2481 (61.4%)     | 683 (62.7%)   |             |
| Arrival time  |                   |               |             |                   |               |             |
| 8:00–15:00    | 583 (21.1%)       | 176 (20.0%)   | .817        | 824 (20.4%)      | 179 (16.4%)   | .002*       |
| 15:00–18:00   | 543 (19.7%)       | 184 (20.9%)   |             | 764 (18.9%)      | 207 (19.0%)   |             |
| 18:00–22:00   | 864 (31.3%)       | 280 (31.7%)   |             | 1206 (29.8%)     | 392 (36.0%)   |             |
| 22:00–8:00    | 727 (26.4%)       | 236 (26.8%)   |             | 1188 (29.4%)     | 310 (28.4%)   |             |
| Missing       | 41 (1.5%)         | 6 (0.7%)      |             | 60 (1.5%)        | 2 (0.2%)      |             |
| ISS           |                   |               |             |                   |               |             |
| Median [Q1, Q3]| 4 [4, 9]         | 4 [4, 9]      | .656        | 4 [3, 9]         | 5 [4, 10]    | <.001*      |
| Missing       | 97 (3.5%)         | 32 (3.6%)     |             | 147 (3.6%)       | 36 (3.3%)     |             |
| ICU length of stay | 2 [0, 3]        | 1 [0, 3]     | .075        | 1 [0, 3]        | 2 [1, 3]     | <.001*      |
| Missing       | 2140 (77.6%)      | 701 (79.5%)   |             | 3078 (76.2%)     | 844 (77.4%)   |             |
| ICU admission |                   |               |             |                   |               |             |
| Yes           | 330               | 95            | .336        | 517              | 157          | .162        |
| No            | 2428              | 787           |             | 3525             | 933          |             |
| Admitting service |            |               |             |                   |               |             |
| Critical care | 113 (4.1%)        | 33 (3.7%)     | .761        | 144 (3.6%)       | 34 (3.1%)    | .026*       |
| Face          | 333 (12.1%)       | 86 (9.8%)     |             | 531 (13.1%)      | 116 (10.6%)  |             |
| General surgery | 953 (34.6%)     | 317 (35.9%)   |             | 1380 (34.1%)     | 442 (40.6%)  |             |
| GU            | 11 (0.4%)         | 2 (0.2%)      |             | 18 (0.4%)        | 4 (0.4%)     |             |
| Hand          | 6 (0.2%)          | 2 (0.2%)      |             | 11 (0.3%)        | 2 (0.2%)     |             |
| Neuro         | 94 (3.4%)         | 26 (2.9%)     |             | 159 (3.9%)       | 44 (4.0%)    |             |
| Nonsurgical   | 124 (4.5%)        | 35 (4.0%)     |             | 149 (3.7%)       | 36 (3.3%)    |             |
| Orthopedic surgery | 421 (15.3%) | 140 (15.9%) |             | 591 (14.6%)      | 170 (15.6%)  |             |
| Plastic surgery | 36 (1.3%)       | 11 (1.2%)     |             | 48 (1.2%)        | 22 (2.0%)    |             |
| Missing       | 667 (24.2%)       | 230 (26.1%)   |             | 1010 (25.0%)     | 219 (20.1%)  |             |

* Statistically significant difference between 2020 and the historical average.

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### Table 3

Mechanism of injury post-SIP compared to date-matched controls

| Mechanism of injury | 2017–2019 | 2020 | P value |
|---------------------|-----------|------|---------|
|                     | (N = 4042)| (N = 1090) |       |
| Animal              | 127 (3.1%)| 44 (4.0%) | 1       |
| Assault             | 38 (0.9%) | 16 (1.5%) | 1       |
| Blunt               | 376 (9.3%)| 80 (7.3%) | .815    |
| Crush               | 40 (1.0%) | 12 (1.1%) | 1       |
| Exposure/burn       | 156 (3.9%)| 40 (3.7%) | 1       |
| Fall                | 1630 (40.3%)| 400 (36.7%) | .637    |
| Gunshot             | 71 (1.8%) | 36 (3.3%) | .038    |
| Stab/lacerations    | 68 (1.7%) | 24 (2.2%) | 1       |
| Motorized vehicle   | 817 (20.2%)| 201 (18.4%) |       |
| Nonaccidental trauma| 94 (2.3%) | 21 (1.9%) | 1       |
| Nonmotorized vehicle| 360 (8.9%)| 163 (15.0%) | <.001 |
| Pedestrian          | 171 (4.2%)| 27 (2.5%) | .1134   |
| Unknown/other       | 75 (1.9%) | 16 (1.5%) | 1       |
| Missing             | 19 (0.5%) | 9 (0.8%)  |         |

* Statistically significant difference between 2020 and the historical average.
data analysis, and provided critical review of the manuscript including revisions.

Dr Urrechaga, Dr Thorson, Dr Russell, Dr Acker, Dr Malvezzi, Dr Fuchs, Ms Rohan, and Ms Swain coordinated and supervised data collection at their corresponding institutions and provided critical review of the manuscript including revisions.

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

Conflict of Interest

The authors have no conflicts of interest relevant to this article to disclose.

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