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Impact of “Stay-at-Home” orders on non-accidental trauma: A multi-institutional study

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ABSTRACT

Background: It is unclear how Stay-at-Home Orders (SHO) of the COVID-19 pandemic impacted the welfare of children and rates of non-accidental trauma (NAT). We hypothesized that NAT would initially decrease during the SHO as children did not have access to mandatory reporters, and then increase as physicians’ offices and schools reopened.

Methods: A multicenter study evaluating patients <18 years with ICD-10 Diagnosis and/or External Cause of Injury codes meeting criteria for NAT. “Historical” controls from an averaged period of March–September 2016–2019 were compared to patients injured March–September 2020, after the implementation of SHO (“COVID” cohort). An interrupted time series analysis was utilized to evaluate the effects of SHO implementation.

Results: Nine Level I pediatric trauma centers contributed 2064 patients meeting NAT criteria. During initial SHO, NAT rates dropped below what was expected based on historical trends; however, thereafter the rate increased above the expected. The COVID cohort experienced a significant increase in the proportion of NAT patients age ≥5 years, minority children, and least resourced as determined by social vulnerability index (SVI).

Conclusions: The COVID-19 pandemic affected the presentation of children with NAT to the hospital. In times of public health crisis, maintaining systems of protection for children remain essential.

Level of evidence: III

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1. Background

Child abuse is a serious and pervasive public health issue that has significant repercussions for long-term physical and mental

health. The National Survey of Children’s Exposure to Violence found that almost 40% of children had experienced some kind of physical abuse within one year [1]. Furthermore, it is known that as unemployment rates increase, the rate of child abuse increases – each 1% increase in unemployment is associated with at least a 0.50 per 1000 increase in confirmed child abuse reports [2].

In 2020, the COVID-19 pandemic created a new reality for people across the world. Across the United States, as social distanc-

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ing was implemented, many non-essential businesses closed and unemployment increased. Schools closed and therefore children were more often at home, potentially compounding family stressors. Concern developed over the welfare of children and a potential rise in child abuse [3–8]. In order to decrease the risk of child abuse, the American Academy of Pediatrics (AAP) issued an advisory statement to reach out for help during this stressful time and practice safe discipline techniques [9]. Despite many statements from experts and international organizations on the suspected rise in child abuse during the pandemic, there is limited evidence documenting this change [3–7,10,11].

Because of the potentially increased risk of non-accidental trauma (NAT) during and following Stay-at-Home Orders (SHO), we investigated the impact of the COVID pandemic on NAT by evaluating changes in NAT rates before and after SHO implementation. We hypothesized that the rate of NAT would initially decrease during the SHO as children lacked access to mandatory reporters (such as schoolteachers and primary care providers) and then increase as schools and physician offices started to reopen.

2. Methods

2.1. Data source and study population

Nine Level I Pediatric Trauma Centers participated in this multicenter, retrospective study through the Midwest Pediatric Surgery Consortium (MPWSC; www.mwpssc.org). Institutional Review Board (IRB) approval and Data Use Agreements (DUA) were obtained at each site, with Children's Wisconsin acting as the Data Coordinating Center (DCC) (IRB#1,663,147). The reporting of this study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.

Institutional trauma registries were queried from January 1, 2016–September 30, 2020 for patients <18 years of age with traumatic injuries as defined by the National Trauma Data Bank (NTDB). Patients included in institutional trauma registries that did not meet these criteria were excluded from the study. The study population was split into two cohorts. The first cohort was comprised of patients who arrived at the hospital after the implementation of SHO (March–Sept 2020), thus was assigned the “COVID” cohort. SHO initiation dates were defined based on each site's local and state ordinances (Supplement 1). The comparative group was a historical control and was an averaged population from the corresponding SHO dates for each site during the four preceding years, March–Sept 2016–2019. Use of an averaged comparator was meant to limit any potential aberrations seen in any one year. A sensitivity analysis using just 2019 data was performed to control for changes over time. Statistical testing was performed comparing the difference between 2019 and HA and there was no significant difference.

NAT was identified by the following ICD-10 Diagnosis and/or External Cause of Injury codes: T74 (“Adult and child abuse, neglect and other maltreatment, confirmed”), T76 (“Child physical abuse, suspected”), Z04 (“alleged child physical abuse”), and/or Y07 (“Perpetrator of assault, maltreatment and neglect”). In concordance with the Centers for Disease Control (CDC) and the American College of Surgeons (ACS), child abuse, or nonaccidental trauma, was defined as deliberate or intentionally inflicted injury [12,13]. Data throughout each hospital encounter until disposition were evaluated.

2.2. Statistical analysis

Demographics included age, gender, race, ethnicity, Injury Severity Scores (ISS), and several metrics of social determinants of health. The CDC's Social Vulnerability Index (SVI) measures and

ranks each census tract based on 15 social factors, such as poverty, lack of vehicle access, and crowded housing. The SVI ranges from 0 to 1, with 1 indicating areas with the highest vulnerability. The Area Deprivation Index (ADI) was created by the Health Resource and Services Administration (HRSA) to determine the socioeconomic disadvantage of neighborhoods based on income, education, employment, and housing quality. Census tracts are given a percentile ranking from 1 (least disadvantaged) to 10 (most disadvantaged). 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 [14]. The Gini Index is a measure of wealth inequality within a certain population, where 0 is uniform income distribution and 1 is severe unequal distribution.

Outcomes were defined as mortality, hospital disposition, intensive care unit and hospital length of stay, and days on mechanical ventilation. Categorical variables were assessed using the Pearson Chi Square test. For continuous, normally distributed variables, the Student's *t*-test was used, whereas Wilcoxon rank-sum was used with non-normally distributed data. The monthly rate of NAT was compared between cohorts with the addition of a LOESS smoothing line. Interrupted time series analysis (ITSA) with autoregressive integrated moving average (ARIMA) was used to evaluate differences in the expected and observed rates of NAT. An averaged date of the sites' initiation of SHO was used as the “interruption” within the model.

To assess the multifactor effect on NAT, we analyzed the relationship of age, race, gender, SVI, COVID cohort (hence, injury occurring after SHO in 2020) on NAT as compared to any other injury type, using generalized regression modeling (GRM) with a binomial (i.e. logistic) family link and controlling for clustering by site. The population was limited to January through September for each year to minimize confounding by the October through December populations from historical years. Because of the relative infrequency of NAT compared to all other injuries, a smaller sample from the ‘all other injured group’ was taken using simple random sampling (SRS) to numerically balance the groups for an additional sensitivity analysis. This was bootstrapped and the average of 10,000 random models was taken. Lastly, to explore potential effect modification from COVID on the association between SVI and NAT, we tested an interaction term between cohort and SVI in the final model. Significance was accepted at $p < 0.05$. All analyses were performed using R statistical software (RStudio, version 1.4.1717 © 2009–2021 RStudio, PBC) [15].

3. Results

A total of 47,385 pediatric trauma patients between Jan 1, 2016 and Sept 30, 2020 met study inclusion criteria, of which 5.6% (2,663) had documented NAT. From the SHO initiation dates through September of each year, there was a cumulative total of 1398 NAT patients, 51.7% of all NAT (Supplement 2). The COVID cohort included 26% more NAT patients than the averaged Historical control (335 patients vs. 266 patients, respectively), although the proportion of NAT compared to all injuries did not change (COVID 4.74% vs. Historical 4.52%; $p = 0.577$), as there was a proportionally similar increase in total traumatic injuries in the COVID cohort. In the NAT patients, there was a significant difference in median age, with the COVID cohort being significantly older than that of the Historical control (COVID 2 years, IQR 0.5–6 years vs. Historical 1 year, IQR 0.3–2 years, $p < 0.001$). There was a significant difference in the distribution of race and ethnicity between cohorts (Table 1). The mean SVI and ADI was significantly higher in the COVID cohort, signaling an increase in vulnerability (Table 1).

Table 1
Demographic and Injury Characteristics, No. (%).

	Historical average 2016–2019, total N = 1063 averaged N = 266	COVID2020 N = 335	p-value
Gender, Male	160 (60.2)	216 (64.5)	0.315
Age, years			
< 5	230 (86.5)	232 (69.3%)	<0.001
≥5	36 (13.5)	103 (30.8%)	
Median age, years (IQR)	1.0 (IQR 0.3–2)	2.0 (0.5–6)	<0.001
Race			
White	162 (60.9)	161 (48.1)	0.002
African American	82 (30.8)	137 (40.9)	0.014
Other	22 (8.3)	37 (11)	0.319
Ethnicity			
Hispanic	17 (6.4)	19 (5.7)	0.845
Non-Hispanic	210 (79.0)	301 (89.9)	<0.001
Unknown/Missing	39 (14.7)	15 (4.5)	<0.001
Weighted Average SVI, (SD)	0.54 (0.22)	0.57 (0.21)	0.01
Weighted Average ADI, (SD)	0.39 (0.11)	0.41 (0.11)	0.01
Weighted Average Gini Index, (SD)	0.44 (0.05)	0.44 (0.05)	0.53
Injury Severity Score (ISS)			
0–15	190 (73.6)	244 (74.4)	0.913
16–25	36 (14)	55 (16.8)	0.413
>25	32 (12.4)	29 (8.8)	0.206
Mean ISS, (SD)	10.7 (9.3)	9.9 (8)	0.17
Injury Type			
NAT	266 (4.5)	335 (4.7)	0.577
All other types	5623 (95.5)	6733 (95.3)	
Injury Location			
Same as home zip	184 (88)	218 (80.2)	0.028
Different than home zip	25 (12)	54 (19.9)	
Head Injury	174 (65.4)	177 (52.8)	0.002

The COVID cohort had significantly more patients injured away from home, as defined by injury occurring in a zip code different from their resident zip code (COVID 19.9% vs. Historical 12%, $p = 0.028$). Lastly, there was a significant decrease in the proportion of NAT patients with head injuries (COVID 52.3% vs. Historical 65.4%, $p = 0.01$). Although there was no statistical difference in overall mortality (COVID 6% vs. Historical 5.4%), the COVID cohort had significantly more deaths in the Emergency Department (ED) (COVID 40% vs. 7.1%, $p = 0.05$). Interestingly, there was a smaller proportion of severely injured (ISS >25) NAT patients in 2020 compared to the Historical control (COVID 8.8% vs. Historical 12.4%, $p = 0.131$), which may reflect the increase in ED deaths during this period. Findings were similar in the sensitivity analysis comparing only 2019 to the COVID cohort (Supplement 3), although the magnitude of the increase was decreased. There were no other significant differences in outcomes (Supplement 4).

After initiation of SHO, there was an initial decrease in NAT, with a subsequent rise beginning in June 2020 (Fig. 1). This finding was also demonstrated on the ITSA, where after the start of SHO, observed rates of NAT dropped below the expected rate. However, subsequently there was a rise in observed NAT above that expected (Fig. 2).

Among the 30,622 children injured between January and September across all years, after controlling for age, race, SVI, and site clustering, patients injured after SHO in 2020 were at higher odds of NAT compared to other types of injury (OR 1.17, 95% CI 1.02–1.34, $p = 0.024$) (Table 2). This association remained in the simple random sampling (SRS) comparison with children having 33% higher odds of presenting with NAT during COVID compared to prior years (OR 1.33 95% CI 1.32–1.33, $p = 0.005$). African American race and increasing SVI (i.e. worsening resources) were also associated with higher odds of NAT during COVID (Table 2). The interaction term between SVI and cohort was statistically significant, and stratified analyses demonstrated the strength in the relationship between SVI and NAT was greater in the COVID era than HA (COVID aOR 4.38, 95% CI 2.45–7.92 vs. Historical aOR 2.18, 95% CI 1.57–3.03).

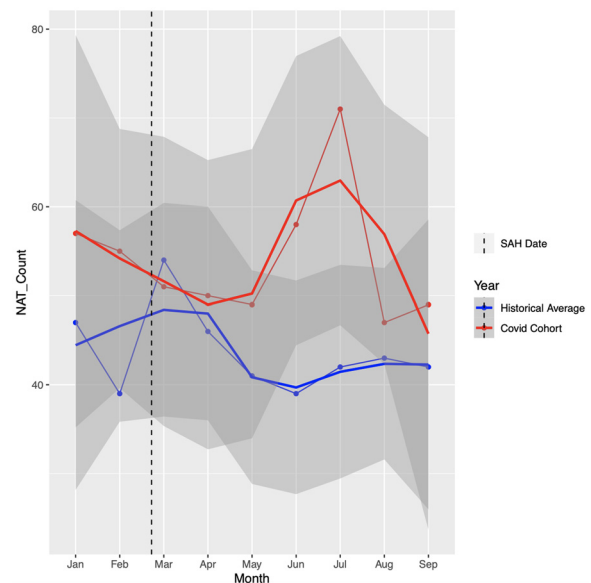


Fig. 1. Frequency of nonaccidental trauma (NAT) injuries by month across all sites with a LOESS smoothing line.

4. Discussion

This study demonstrates significant associations between SHO because of COVID and patterns of NAT. During the initial six months of the pandemic, the volume of NAT increased and this change was appreciably greater among older children, as well as more minority patients. The proportion of NAT remained similar, because of an overall increase in pediatric trauma during this time, most notably from an increase in firearm, bicycle, and ATV injuries. Patients with NAT in 2020 also had increased SVI and ADI which may reflect the financial and emotional strain broadly inflicted on families during the pandemic. The risk of NAT in 2020 was signifi-

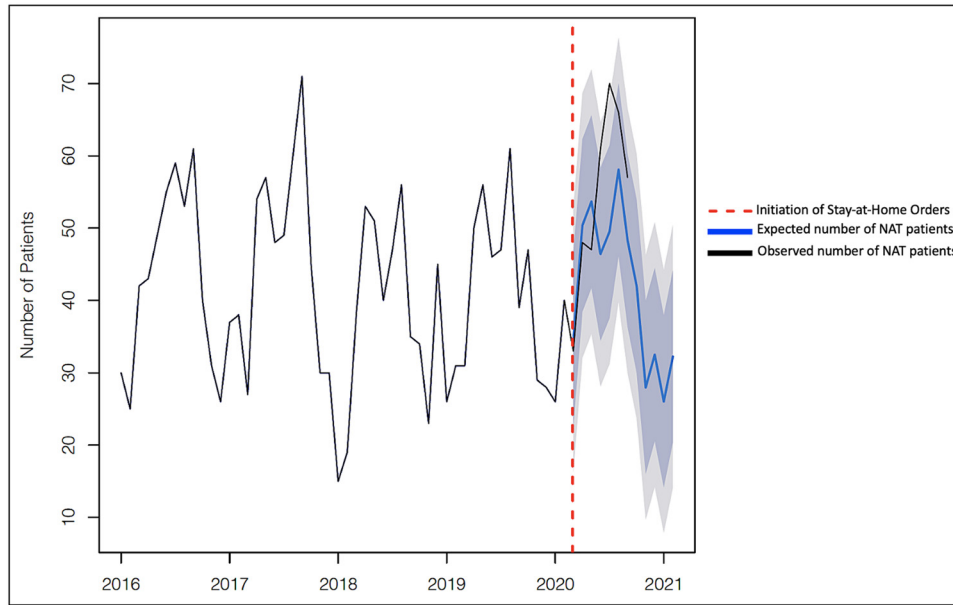


Fig. 2. Interrupted Time Series Analysis (ITSA) for Nonaccidental Trauma (NAT) with Stay-at-Home Orders (SHO) as the interruption.

Table 2
Multivariate regression with actual population and balanced with simple random sampling (SRS)*.

Variable	Actual Population		Balanced with SRS	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Historical Control	Ref	–	Ref	–
COVID Cohort	1.17 (1.02–1.34)	0.026	1.33 (1.32–1.33)	0.05
Age, years				
< 1	25.16 (20.80–30.68)	<0.001	35.05 (34.96–35.13)	<0.001
1–4	4.37 (3.58–5.38)	<0.001	5.06 (5.05–5.07)	<0.001
5–9	Ref	–	Ref	–
10–14	0.57 (0.42–0.77)	<0.001	0.57 (0.57–0.57)	0.004
15–17	0.89 (0.64–1.21)	0.461	0.70 (0.70–0.70)	0.10
Race				
Caucasian	Ref	–	Ref	–
African American	2.09 (1.81–2.41)	<0.001	2.84 (2.84–2.85)	<0.001
Minority, other	1.19 (0.90–1.55)	0.205	1.10 (1.09–1.10)	0.592
Other	0.86 (0.63–1.15)	0.310	0.83 (0.83–0.83)	0.444
Social Vulnerability Index (SVI), Decile				
1st, most resourced	Ref	–	Ref	–
2nd	1.74 (1.07–2.89)	0.034	1.88 (1.87–1.89)	0.151
3rd	1.66 (1.02–2.84)	0.05	1.72 (1.71–1.73)	0.217
4th	1.86 (1.15–3.17)	0.016	1.91 (1.90–1.92)	0.135
5th	2.41 (1.52–4.06)	<0.001	2.50 (2.49–2.51)	0.028
6th	2.26 (1.43–3.8)	0.001	2.47 (2.46–2.48)	0.029
7th	2.56 (1.61–4.31)	<0.001	2.34 (2.33–2.35)	0.044
8th	2.73 (1.69–4.63)	<0.001	2.79 (2.77–2.79)	0.020
9th	3.25 (2.01–5.55)	<0.001	3.50 (3.49–3.51)	0.005
10th, least resourced	2.21 (1.14–4.33)	0.019	2.91 (2.89–2.93)	0.130

* Association between the COVID pandemic and NAT, controlling for demographic factors and clustering by site, among both the actual population and that balanced with simple random sampling (SRS).

cantly increased by the COVID pandemic and the associated SHOs, with the highest risks in African American children and children with fewer sources (higher SVI).

Our study found more older children suffered NAT after SHO implementation. The median age almost doubled in the COVID cohort; the mean age in 2020 was 4.4 years compared to 2.5 years. This may reflect that school-aged children were more often at home, without access to the controlled conditions of a classroom, thus were more vulnerable to NAT. While younger children and infants are more likely to suffer head injuries from abuse [16], the COVID cohort experienced significantly fewer head injuries than historical control potentially because they were older. This may also reflect variability in daycare closures across states. Despite

school closures, in some regions, daycare centers were considered essential businesses and remained open. As such, many infants and toddlers may not have been as consistently at home as school-aged children. During 2020, children were more likely to suffer NAT injuries away from home, which may possibly represent the fact that although schools and non-essential businesses closed, many parents continued to work at essential businesses, requiring friends or relatives outside the home to provide childcare. However, this study is limited by the absence of data available regarding the perpetrators of the abuse.

As schools and physicians' offices closed during SHO, it is possible there was a delay in definitive care for patients with NAT. In addition, many people avoided hospitals and clinics because of

the fear of becoming infected with the SARS-Cov2 virus. This may in part explain the increase in the number of patients who died in the ED and subsequent change in distribution of injury severity compared to previous years. In the COVID cohort, a smaller proportion of severely injured NAT patients were seen. Severely injured patients may have experienced a delay in care and thus did not survive to the hospital to be included in the higher ISS group. This is in contrast to smaller, single institution studies which showed no significant difference in the injury severity of child abuse patients during COVID compared to prior years [17–19].

There were definite temporal variations in rates of child abuse. The majority of studies regarding child abuse during the COVID pandemic used the time period immediately after the SHO in March to May or June reported decreased rates of child abuse presentation, reports, or investigations during this early time period, which our study corroborates [18,20–24]. Barboza et al. showed that although overall rates of child abuse decreased during the first 4 months of the pandemic, areas with deficiencies in many social determinants of health were associated with new “hot spots” of child abuse [24]. Using ARIMA techniques, Whelan et al. showed that criminal filings for child abuse decreased more than 25% from expected from February to June 2020 [20]. Several single institution studies reported no change or even a decrease in the proportion of NAT in the first 2–3 months of the pandemic [18,21]. Furthermore, similar to our findings, studies with a more longitudinal approach observed a relative increase in child abuse reporting or presentation in the summer months [11,19,25]. Sharma et al. evaluated all ED patients who had a child abuse report filed [19]. Compared to historical rates, there was an increase in child abuse reports in May and June of 2020, particularly with reports of psychological abuse and non-medical neglect [19]. These longitudinal data confirm our hypothesis that abuse rates would increase as clinics and schools reopened.

This was a retrospective study with all its inherent limitations. Our data lacked information regarding home life and/or parent/caregiver demographics. Our data source was the institutional trauma registries and were limited to ICD-10 codes; reports and investigations of child abuse were not used in our analysis. We only included patients that met trauma registry inclusion criteria and did not include patients seen and discharged from the ED, seen in healthcare settings other than the hospital, those that had injuries that did not meet NTDB inclusion criteria, or those without physical injuries. These limitations, however, should be consistent across time and therefore unlikely to impact the associations identified in this study.

While Stay-at-Home Orders may help mitigate an infectious pandemic, a potential unintended consequence is increased exposure of children to physical and/or emotional abuse, and the most vulnerable children appeared to be most negatively impacted. Child abuse experts have expressed concern that the decreased rate of child abuse reports is a façade and that more children are experiencing unreported abuse [25]. This study confirms that NAT did not decrease during the pandemic. When access to social services resumed, the rate of NAT presenting to trauma centers increased. Even during a national crisis, systemic safeguards such as social services that help families, particularly those least resourced and most vulnerable, should be considered essential.

Type of study

Retrospective, comparative study

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jpedsurg.2022.01.056.

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