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Association of Economic Recession and Social Distancing With Pediatric Non-accidental Trauma During COVID-19

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ABSTRACT

Introduction: There has been concern that the incidence of non-accidental trauma (NAT) cases in children would rise during the COVID-19 pandemic due to the combination of social isolation and economic depression. Our goal was to evaluate NAT incidence and severity during the pandemic across multiple US cities.

Methods: Multi-institutional, retrospective cohort study comparing NAT rates in children <18 y old during the COVID-19 pandemic (March-August 2020) with a recent historical data (January 2015-February 2020) and during a previous economic recession (January 2007-December 2011) at level 1 Pediatric Trauma Centers. Comparisons were made in local and national macroeconomic indicators.

Results: Overall rates of NAT during March-August 2020 did not increase compared to historical data ($P = 0.8$). Severity of injuries did not increase during the pandemic as measured by Glasgow Coma Scale (GCS) ($P = 0.97$) or mortality ($P = 0.7$), but Injury Severity Score (ISS) slightly decreased ($P = 0.018$). Racial differences between time periods were seen, with increased proportions of NAT occurring in African-Americans during the pandemic ($P < 0.001$). NAT rates over time had low correlation ($r = 0.32$) with historical averages, suggesting a difference from previous years. Older children (≥ 3 y) had increased NAT rates during the pandemic. Overall NAT rates had low inverse correlation with

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unemployment ($r = -0.37$) and moderate inverse correlation with the stock market ($r = -0.6$). Significant variation between sites was observed.

Conclusions: Overall NAT rates in children did not increase during the COVID-19 pandemic, but rates were highly variable by site and increases were seen in African-Americans and older children. Further studies are warranted to explore local influences on NAT rates.

Introduction

There have been concerns that social distancing measures and subsequent social isolation during the SARS-CoV-2 (COVID-19) pandemic may lead to increased rates of child physical abuse, also known as non-accidental trauma (NAT). Increased rates of NAT have been observed during previous economic downturns, including the 2008-2009 Great Recession, which brought increased rates of abusive head trauma.[1,2] In addition to increases in absolute numbers, the severity of NAT increased during that recession,[2] and several studies have linked child abuse with mortgage delinquency and unemployment.[3,4]

The economic recession and high unemployment rates observed during the COVID-19 pandemic are concerning for possible increases in NAT. Unfortunately, along with the recession, came shelter-in-place guidelines, school closures, and other social distancing measures. Thus, there has been intense speculation that the incidence in NAT cases would rise during the pandemic due to the dual impact of social isolation and economic depression.[5,6] An increase in intimate partner violence was reported early in the pandemic, with some suggesting this was secondary to stay-at-home policies.[7,8] In addition, some early studies found increases in child abuse during COVID-19, while others noted a decrease in the number of NAT cases seen compared to previous years.[9-14]

This study sought to evaluate changes in NAT incidence and severity during the COVID-19 pandemic across multiple diverse US cities. Our *a priori* hypothesis was that an initial drop in NAT incidence would be seen at the onset of the pandemic while lockdown measures were in place, with a subsequent rise in numbers and severity as these measures were relaxed and the effects of social distancing and economic depression become more visible.

Methods

This was a multi-institutional, retrospective, cohort study of pediatric patients suspected to be victims of NAT. Institutional review board approval was obtained at all sites. Participating sites included Le Bonheur Children's Hospital (Memphis, TN), Comer Children's Hospital (Chicago, IL), Cincinnati Children's Hospital Medical Center (Cincinnati, OH), Nationwide Children's Hospital (Columbus, OH) and New York-Presbyterian Morgan Stanley Children's Hospital (New York, NY). All sites are American College of Surgeons-verified, or State-verified, Level 1 Pediatric Trauma Centers (PTC) and have a dedicated child abuse team. Each site's Institutional

Review Board approved this study as non-human subjects research and granted waiver of informed consent. Formal data use agreements were executed between each site and the lead site (Le Bonheur Children's Hospital) to enable centralized data collection and analysis.

Children <18 y old with injuries suspected to be due to NAT seen in the emergency room or inpatient were included in the study. Our primary study period was March-August 2020. Patients from 2007 to 2011 provided comparison data from before, during and after the economic Great Recession (December 2007-June 2009). Children from January 2015-February 2020 represented a historical comparison without an economic recession or pandemic. Patients 18 y or older were excluded. Patients were identified using institutional trauma registries based on ICD9 (995.50, 995.54, 995.55) and ICD10 codes (T74.92, T76.92, T76.12) and data were obtained from the electronic medical records. Patient demographics were collected including age, sex, race, county and zip code of residence, insurance type, mechanism of injury, disposition (including mortality), and severity of injury as measured by Glasgow Coma Scale (GCS) and Injury Severity Score (ISS).

The primary outcome measure of this study was the rate of suspected NAT during the COVID-19 pandemic. Rates of NAT are expressed as the number of suspected NAT patients per trauma admissions over the specified time periods. Secondary outcomes included, association of suspected NAT with macroeconomic indicators, and the severity of NAT and mortality rates during the study periods.

Economic indicators used in this study included monthly national and local (e.g.., city-level) unemployment rates, obtained from the U.S. Bureau of Labor Statistics,[15,16] as well as Dow Jones Industrial Average (DJIA) historical data.[17] The daily closing value of the DJIA was averaged to create a monthly closing average. For this study, the COVID pandemic in the U.S. was defined as starting in March 2020. Data were also compared by age groups: infants under 1 y of age (<1), children between the ages 1-2 y (1-2), and children 3 y and older ($\geq$3).

Chi-square and Kruskal−Wallis tests were used for categorical data and Mann−Whitney and Kruskal−Wallis tests were used for continuous variables when appropriate. P-values <0.05 were considered significant. Pearson Correlation Coefficients were used to measure the correlation between trendlines. Coefficients (r) were considered to have no/negligible correlation if between 0.0 and 0.3, low correlation from 0.3 to 0.5, moderate correlation from 0.5 to 0.7, high correlation from 0.7 to 0.9 and very high correlation for 0.9-1.0. Negative coefficients were indicative of an inverse relationship. All data were non-parametric and reported in median and interquartile range (IQR). Missing data were

Table 1 — Patient demographics by site.							
Variable	All	Memphis	Chicago	Cincinnati	Columbus	New York	P-value
Total (N)	3598	715	725	679	1249	230	—
Gender, n (%)							
Male	2141 (60%)	417 (58%)	431 (59%)	422 (62%)	741 (59%)	130 (57%)	0.52
Female	1454 (40%)	298 (42%)	293 (40%)	257 (38%)	508 (41%)	100 (43%)	
Race, n (%)							
White	1683 (47%)	212 (30%)	61 (8.4%)	456 (67%)	848 (68%)	106 (47%)	**< 0.0001**
African-American	1189 (33%)	448 (63%)	238 (33%)	177 (26%)	264 (21%)	62 (27%)	
Asian	12 (0.3%)	0 (0%)	0 (0%)	0 (0%)	10 (0.8%)	2 (0.9%)	
Other	234 (6.5%)	54 (7.5%)	32 (4.4%)	46 (6.7%)	68 (5.4%)	34 (15%)	
Unknown	480 (13%)	1 (0.1%)	394 (54%)	0 (0%)	59 (4.7%)	26 (11%)	
Insurance type, n (%)							
Private	401 (11%)	47 (6.6%)	—	116 (17%)	189 (15%)	49 (21%)	**< 0.0001**
Public	2168 (61%)	605 (85%)	—	478 (70%)	923 (74%)	180 (78%)	
Self-Pay	217 (6.1%)	37 (5.2%)	—	45 (6.6%)	134 (11%)	1 (0.4%)	
Other	27 (0.8%)	25 (3.5%)	—	2 (0.3%)	0 (0%)	0 (0%)	
Unknown	767 (21%)	1 (0.1%)	725 (100%)[*]	38 (5.6%)	3 (0.2%)	0 (0%)	
Age (y) median (IQR)	0.75 (0.25-2)	0.67 (0.3-1.9)	1.25 (0.3-3.1)	0.75 (0.25-2)	0.75 (0.25-1.8)	0.58 (0.17-2)	**< 0.0001**
Age group, n (%)							
<1 y	1989 (55%)	427 (60%)	318 (44%)	380 (56%)	723 (58%)	141 (61%)	**< 0.0001**
1-2 y	950 (26%)	189 (26%)	198 (27%)	174 (26%)	356 (29%)	36 (16%)	
≥3 y	659 (18%)	102 (14%)	209 (29%)	125 (18%)	170 (14%)	53 (23%)	
GCS, median (IQR)	15 (15-15)	15 (15-15)	15 (14-15)	15 (15-15)	15 (15-15)	15 (15-15)	**< 0.0001**
ISS, median (IQR)	9 (4-16)	9 (4-17)	9 (4-16)	9 (2-17)	9 (2-13)	9 (4-10)	**< 0.0001**
Mortality, n (%)	194 (5.4%)	37 (5.1%)	3 (1.3%)	42 (6.2%)	40 (5.6%)	72 (5.8%)	0.064

P < 0.05 was considered significant and are highlighted by bold.
IQR = Interquartile range, GCS = Glasgow Coma Scale, ISS = Injury Severity Score.
[*] Insurance type was not available for this site. Missing data was not included in analysis.

excluded from the analysis. Statistics were performed using Microsoft Excel (version 16.48) and an R software (version 4.1.0).[18]

Results

Demographics

Across all time periods and sites included in this study, 3598 patients were identified as suspected NAT. Overall demographics and demographics by site are seen in Table 1. The majority of patients were male (60%), predominantly White (47%), publicly-insured (61%), had a median age of 9 months, a median GCS of 15 and a median ISS of 9. Overall mortality was 5.4%. Statistically significant differences were seen between sites in race, insurance type, and age. Statistically significant, but clinically insignificant, differences were seen between sites in GCS and ISS. There was no difference in mortality between sites.

Demographics were compared between time periods: March-August 2020 *versus* historical data from January 2015-February 2020 (Table 2). The rate of NAT relative to all trauma admissions from January 2015-February 2020 was 5.54%; the rate of NAT during the COVID-19 pandemic from

March-August 2020 was 5.42% (P = 0.8). Significant differences were seen in race between time periods (36% White and 49% African-American during the pandemic *versus* 52% White and 40% African-American historically, P < 0.001). No differences in ISS, GCS or mortality rates were seen during the pandemic *versus* historical data.

Aggregate NAT rates

Monthly NAT rates expressed as cases per trauma admission were plotted. In Figure 1A, NAT rates from 2007 to 2009 are seen along with national unemployment rates and DJIA monthly closing averages during the same period. Several spikes in NAT rates were seen during the Great Recession; however, there was no correlation between those NAT rates and unemployment (r = 0.07) or DJIA (r = 0.008).

In Figure 1B, NAT rates by month are seen for the pandemic period, as well as historical average rates from 2015 to 2019, national unemployment rates and DJIA closing monthly averages for 2020. NAT rates had low correlation with the historic average NAT rate (r = 0.32) and are seen outside the IQR from the historical data in February, March, May and July 2020. There was an increase in NAT seen in February (8.98% *versus* 6.37%, P = 0.23), followed by a drop in March (4.76% *versus* 6.76%, P = 0.20), and then increases in May (5.35% *versus* 3.93%, P = 0.28) and July (5.90% *versus* 4.47%,

Table 2 — Patient demographics by time period.

Variable	Jan. 2015-Feb. 2020	Mar.-Aug. 2020	P-value
Total (N)	1958	220	—
Gender, n (%)			
Male	1136 (58%)	134 (61%)	0.46
Female	821 (42%)	86 (39%)	
Race, n (%)			
White	1000 (52%)	80 (36%)	**< 0.0001**
African-American	788 (40%)	107 (49%)	
Asian	8 (0.4%)	1 (0.5%)	
Other	63 (3.2%)	18 (8.2%)	
Unknown	59 (3.0%)	6 (2.7%)	
Insurance type, n (%)			
Private	233 (12%)	21 (9.6%)	0.46
Public	1280 (65%)	129 (58.6%)	
Self-Pay	127 (6.5%)	5 (2.3%)	
Other	11 (0.6%)	0 (0%)	
Unknown	307 (16%)	65 (29.6%)	
Age (y), median (IQR)	0.75 (0.25-2)	0.92 (0.3-2)	0.08
Age group, n (%)			
<1 y	1096 (56%)	113 (51%)	0.42
1-2 y	512 (26%)	63 (29%)	
≥3 y	350 (18%)	44 (20%)	
GCS, median (IQR)	15 (15-15)	15 (15-15)	0.91
ISS, median (IQR)	9 (4-16)	8 (4-11.25)	0.22
Mortality, n(%)	99 (5.1%)	13 (5.9%)	0.70

$P < 0.05$ was considered significant and are highlighted by bold.

IQR = Inter-quartile range; Jan = January; Feb = February; Mar = March; Aug = August; GCS = Glasgow Coma Scale; ISS = Injury Severity Score.

$P = 0.35$). None of these changes were statistically significant. NAT rates during the pandemic had low inverse correlation with 2020 unemployment rates ($r = -0.37$) and moderate inverse correlation with DJIA ($r = -0.60$).

Site level variability in NAT rates

To understand the variability between sites, site level data (organized geographically from West to East) and overall data are presented (Fig. 2). In the first column, NAT rates by site are shown, along with historical averages and local unemployment rates in 2020. The second and third columns show the number of NAT cases and trauma admissions by site, respectively. A rise in the number of NAT cases was seen in Memphis, Chicago, and Columbus, as well as the combined cohort of all five cities, but this did not always coincide with a rise in trauma admissions for these sites. Chicago and Columbus saw significant increases in trauma volume during the summer months of the pandemic, whereas, Memphis and Cincinnati saw a "little change" in their trauma volumes, and New York experienced a decline in the overall trauma and NAT volume.

Memphis' pandemic NAT rates did not correlate with the historical average NAT rate ($r = 0.013$), indicating a significant difference during the pandemic compared to previous years. However, NAT rates in Memphis had a negligible correlation with unemployment rates ($r = -0.25$). In contrast, Chicago's NAT rates had moderate inverse correlation with the historical average ($r = -0.62$), and high correlation with unemployment rates ($r = 0.76$). Cincinnati saw no correlation between pandemic NAT rates and historical rates ($r = 0.07$) but did experience a moderate inverse correlation with unemployment rates ($r = -0.56$). Columbus had moderate correlation between NAT rates and the historical average ($r = 0.62$) and moderate inverse correlation with unemployment rates ($r = -0.59$). Lastly, New York NAT rates had high correlation with the historical average ($r = 0.71$) and moderate inverse correlation with unemployment rates ($r = -0.50$).

NAT rates by age groups

NAT rates were examined by age groups (Table 3). Infancy (<1 y) was the most common age group with NAT (55%), followed by 1-2 y (26%), and then children ≥3 y (18%). NAT rates by age group did not differ from the historical averages (2015-2019) (<1 y: 51% versus 56%, P = 0.5; 1-2 y: 29% versus 26%, P = 0.6; ≥3 y: 20% versus 18%, P = 0.6). Race, insurance type, ISS and GCS all differed significantly between age groups. ISS was significantly higher in those <1 y (median 9 versus 5, $P < 0.0001$). Mortality was highest in the 1-2 y age group (7.4%), followed by those ≥3 y (6.5%) and lowest in infants <1 y (4.1%,

A

B
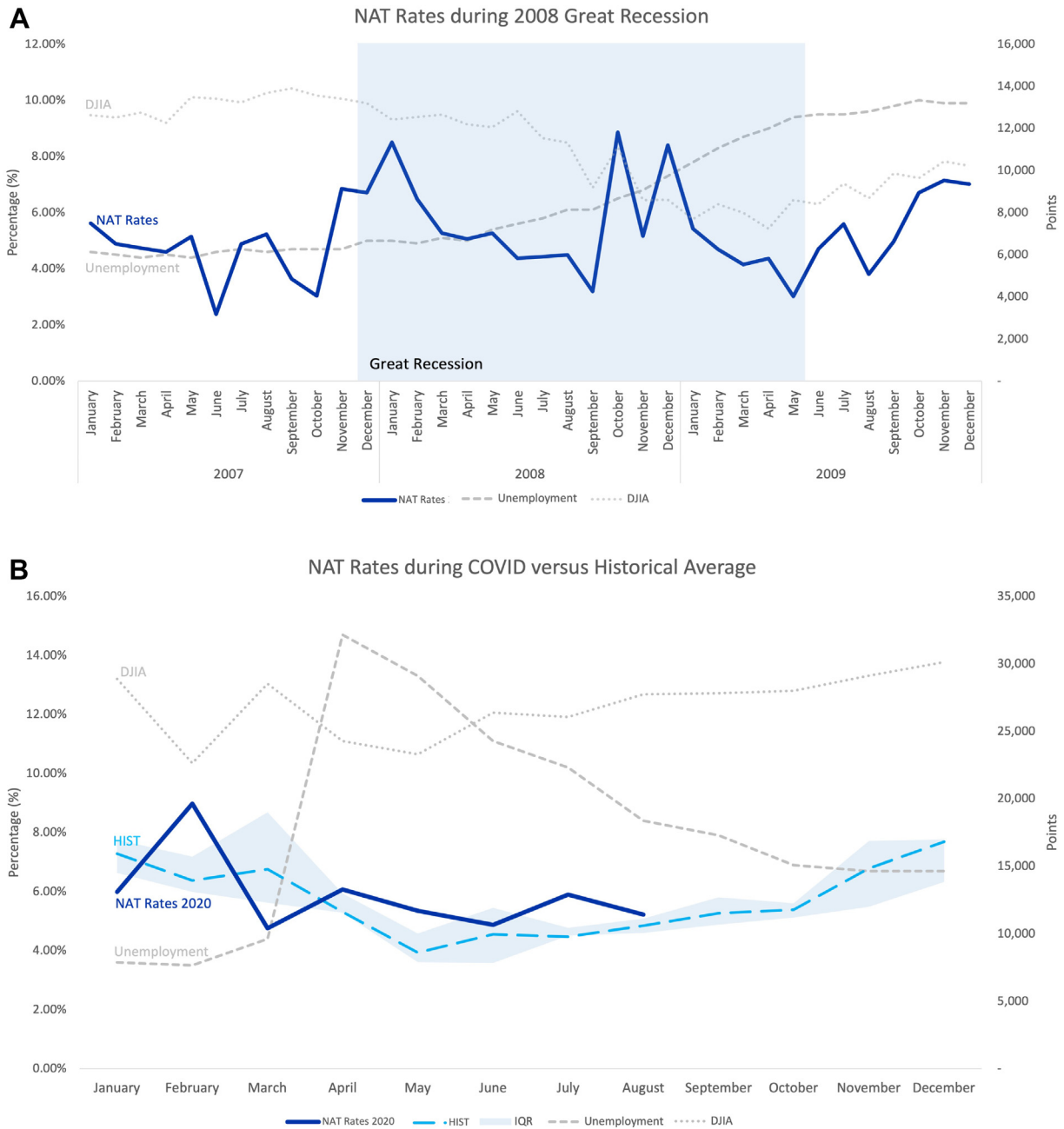
Fig. 1 — Historical NAT rates and during the COVID-19 pandemic. (A) Historical NAT rates (as cases per trauma admission, %) during the Great Recession of 2008-2009. (B) NAT rates during the COVID-19 pandemic and national unemployment rates (%) and DJIA average closing values (Points) in 2020. HIST = monthly average NAT rate from 2015 to 2019. IQR = interquartile range for 2015-2019. DJIA = Dow Jones Industrial Average.

$P < 0.0001$). Statistically significant, but clinically insignificant, differences were seen in GCS between age groups.

Finally, NAT rates by age group were plotted (Fig. 3). NAT rates during the pandemic did not correlate with historical NAT averages in any age group (<1 y: $r = -0.27$; 1-2 y: $r = 0.11$; ≥3 y: -0.05), suggesting the pandemic significantly affected the observed rates compared to previous years. For infants <1 y, there was an increase seen in February (2.9% *versus* 1.4% for previous years, $P = 0.16$), a drop in March (0.73% *versus* 1.3%, $P = 0.06$), and increases in May (1.9% *versus* 1.4%, $P = 0.22$) and August (1.9% *versus* 1.3%, $P = 0.7$). None of these changes were statistically significant. There was minimal deviation
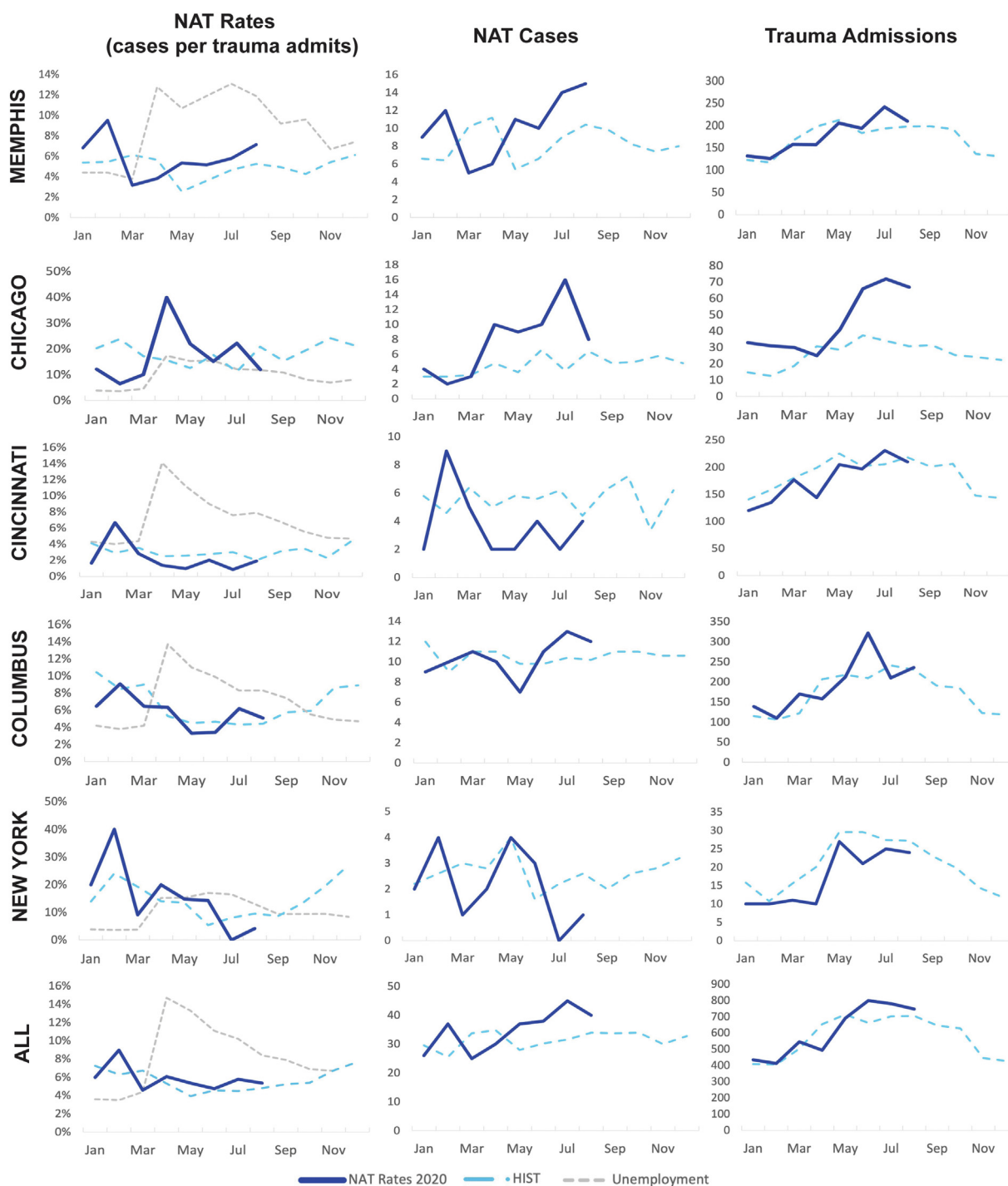
Fig. 2 — NAT cases and trauma admissions in 2020. NAT cases, trauma admissions, and NAT rates (cases per trauma admission) by site and the entire cohort for 2020. HIST = monthly average NAT rate from 2015 to 2019.

from the historic interquartile range seen in the 1-2 y age group. For children ages ≥3 y, rates were least correlated with the historical average, and spikes outside of the historical interquartile ranges were seen in April (2.0% *versus* 0.9%, P = 0.17) and July (1.5% *versus* 1.1%, P = 0.20), but these were not statistically significant.

Discussion

The overall rates of NAT during March-August 2020, the height of the COVID-19 pandemic when social distancing guidelines were in place, did not increase compared to historical data nor did severity of injuries increase. Racial

Table 3 – Demographics by age group.

Age	<1 y	1-2 y	≥3 y	P-value
Total (N)	1989 (55%)	950 (26%)	659 (18.3%)	—
Gender, n (%)				
Male	1162 (58%)	569 (60%)	410 (62%)	0.22
Female	826 (42%)	381 (40%)	249 (38%)	
Race, n (%)				
White	996 (50%)	450 (47%)	237 (36%)	**< 0.0001**
African-American	615 (31%)	323 (34%)	251 (38%)	
Asian	9 (0.45%)	2 (0.21%)	1 (0.2%)	
Other	93 (4.7%)	23 (2.4%)	27 (4.1%)	
Unknown	231 (11.6%)	122 (12.8%)	127 (19.3%)	
Insurance type, n (%)				
Private	262 (13%)	93 (10%)	46 (7.0%)	**< 0.0001**
Public	1297 (65%)	548 (58%)	346 (53%)	
Self-Pay	86 (4.3%)	87 (9.2%)	44 (6.7%)	
Other	14 (0.7%)	9 (0.95%)	4 (0.6%)	
Unknown	335 (16.8%)	213 (22%)	219 (33%)	
GCS, median (IQR)	15 (15-15)	15 (14-15)	15 (15-15)	**0.001**
ISS, median (IQR)	9 (5-16)	5 (1-13)	5 (1-10)	**< 0.0001**
Mortality, n (%)	81 (4.1%)	70 (7.4%)	43 (6.5%)	**< 0.0001**

P < 0.05 was considered significant and are highlighted by bold.
IQR = Interquartile range; GCS = Glasgow Coma Scale; ISS = Injury Severity Score.

differences between time periods were seen, with higher proportions of NAT occurring in African-Americans during the pandemic. NAT rates compared to historical averages demonstrated little correlation, suggesting that NAT rates during the pandemic differed from previous years. However, these did not reach statistical significance, nor did these trends support our hypothesis of an early decrease during social distancing followed by a subsequent rise. We did observe differences by age group, with older children (≥3 y) most affected during the pandemic. NAT rates in aggregate did not correlate with unemployment but had moderate inverse correlation with the DJIA. Importantly, there were variations between sites, suggesting that NAT rates may be more affected by local, rather than national, determinants.

This study highlights that regional differences are crucial to understanding the effects of the COVID-19 pandemic on NAT rates. Memphis' overall NAT cases increased, while trauma admissions were similar to previous years, leading to increased NAT rates. Meanwhile, Columbus and Chicago also saw more NAT cases, accompanied by proportional increases in trauma admissions, so NAT rates were not significantly changed. Conversely, Cincinnati observed fewer NAT cases during the study period. These findings are consistent with the available literature. Single center studies from Baltimore, Atlanta and Lubbock found increases in local NAT rates during the pandemic,[11,12,19] while studies from New York City, Dallas, and Los Angeles reported declines in local NAT cases.[9,10,20] This site-to-site variability highlights the importance of studying NAT epidemiology on multiple scales.

Variability is not limited to NAT rates; single-center studies in San Francisco and New York found no significant increase in pediatric trauma admissions during the pandemic,[21,22] yet, we observed numerous cities in the present study with increased trauma admissions. Several national studies examining NAT during COVID-19 have been published with conflicting results. The Centers for Disease Control and Prevention found a decrease in NAT cases but increased rates of NAT when measured as a proportion of Emergency Department(ED) visits.[23] Several studies utilizing the Pediatric Health Information System found fewer NAT cases.[13,14,24] Another multicenter study from the Western Pediatric Surgery Research Consortium found no increases in NAT during the early months of the pandemic.[25] However, the COVID-19 pandemic affected each community differently, with varying state and city responses, social distancing guidelines and dates, local unemployment rates, etc. Our study focuses on, and exemplifies that local trends may be more important when investigating NAT epidemiology, as many of these local trends are not apparent when data are aggregated on the national scale. The reason beyond these differences is likely multifactorial. One example of this is seen in cities with lower trauma admissions (like San Francisco and New York), that likely had more stringent social distancing guidelines in places with higher compliance, compared to higher rates of trauma seen in Columbus and Chicago. Racial demographics, such as cities like Memphis where there are larger African-American communities seeing increases in NAT rates, likely also contributed to the variations seen.

NAT Rates by Age Group
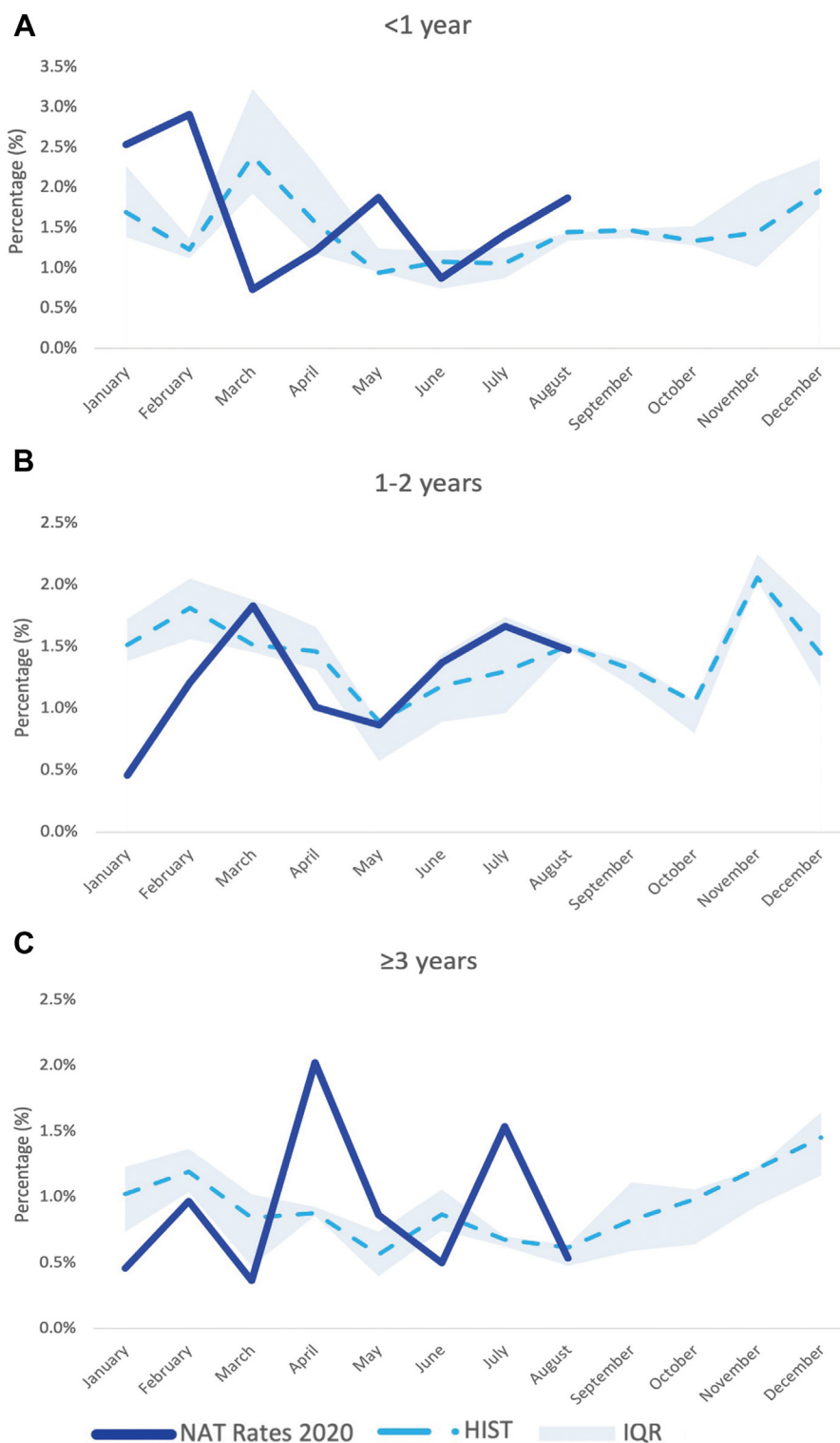
Fig. 3 − NAT rates by age group. NAT rates (as cases per trauma admission, %) by age group for 2020: (A) < 1 y, (B) 1-2 y, (C) ≥ 3 y. HIST = monthly average NAT rate from 2015 to 2019.

Macro-economic indicators may not be appropriate measures to benchmark NAT. The existing literature surrounding the effects of unemployment on NAT is mixed. Some have reported no association between unemployment and child abuse,[4,26] while others suggested a relationship between male unemployment and abuse[27] and one found reduced rates of NAT during a time of increased unemployment.[3] Complex socio-economic and sociodemographic factors make it difficult to isolate the impact of unemployment on NAT relative to other variables. It is interesting to note that NAT cases rose with unemployment rates during the Great Recession, however this was not mirrored during the rise in unemployment at the beginning of the COVID-19 pandemic. It is possible that economic stimulus efforts mitigated this effect. The first round of federal stimulus checks was distributed in April 2020, which may have lessened the impact of unemployment for many families. Previously, Kleven, *et al.* found that the earned income tax credit (which could increase household income) was associated with a reduction in abusive head trauma.[28] In addition, it is possible that the benefits of the economic stimulus did not reach all cities or population groups equally, potentially contributing to variability in NAT incidence between cities. Using the stock market as an economic indicator is similarly fraught with limitations. When the DJIA dropped precipitously in February 2020, a sharp spike in the NAT rate was seen. However, it is possible that this spike is unrelated to the DJIA and instead correlated with the rising COVID-19 infections during that month. Based on our results, we cannot draw a causal relationship between these economic indicators and NAT rates.

The COVID-19 pandemic was more than an economic recession. School closures and social distancing guidelines may have also played a role in the rates of NAT. This may explain differences in NAT rates by age, which may be attributable to differences in typical caretakers for each of the age groups. Children 3 y and older are often in daycare or school, both of which were closed during the early pandemic. Older children were therefore spending most of the time at home in 2020 in contrast to previous years. This may account as to why this age group was most affected, and explain the sharp spikes seen in this age group's NAT rates in April and again in July 2020. Household members are the most common perpetrators of child abuse,[29] which would support this line of reasoning.

This study has limitations. NAT rates were calculated using trauma admissions and therefore do not represent the complete population-based incidence of NAT. Cases of NAT were limited to trauma registries, so they may underrepresent the true number of NAT cases that presented to Child Services with minor injuries or cases that did not reach attention of mandated reporters. However, a recent study found child abuse investigations as a whole decreased substantially during COVID, which was attributed to school closures.[30] This may mitigate this major limitation of this study. Due to limitations in the electronic medical record coding and follow-up, they also represent suspected cases, rather than confirmed cases. Seasonal variations were not factored into this analysis. Differences by site may also affect our results; each site likely has slightly different criteria for trauma activations or admissions and specific signs or symptoms that trigger a NAT

diagnosis.[31,32] However, individual site criteria were unchanged during the study period and should not cause time-related variation. Furthermore, all sites included in this study were in urban centers; while each site has a catchment area that includes rural areas, these results may not be able to be extrapolated to rural areas. Additionally, some urban centers have multiple pediatric trauma centers that may not have been included in this study, which may skew some of the data presented. Furthermore, city-level unemployment rates were used and may not accurately represent each site's full patient catchment area. Patient poverty levels were not collected, which may have been a confounding variable. Lastly, we defined the pandemic as starting in March 2020; however, this may be an oversimplification of the timeline of the pandemic. In some regions cases of COVID-19 were seen earlier and voluntary self-isolation may have taken place before mandatory social distancing was instituted by local governments.

Conclusion

The overall rate of NAT in March-August 2020 did not increase compared to historical data and no difference in injury severity was observed. The economic recession and social distancing guidelines seen during the COVID-19 appear to have played minor roles in the observed trends. Important variations were seen between sites, suggesting differential impacts of the pandemic on individual communities and that additional local factors contributed to variability. This variation between sites highlights the complexity of understanding the true extent of NAT epidemiology to design prevention measures. NAT is a complex public health issue and remains a concern during the remainder of the COVID-19 pandemic and for future pandemics.

Author Contributions

Drs Lewit and Kotagal conceptualized and designed the study, designed the data collection instruments, acquired data, coordinated, and supervised data collection across sites, carried out initial analyses, drafted the manuscript and critically reviewed and revised the manuscript for intellectual content. Drs Gosain and Slidell conceptualized and designed the study, designed the data collection instruments, coordinated, and supervised data collection across sites, drafted the manuscript and critically reviewed and revised the manuscript for intellectual content. Drs Duron, Falcone, Greene, Leonard, Makoroff, Midura, Ramaiah, Mr Fortenberry and Ms Moody acquired data, and critically reviewed and revised the manuscript for intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Disclosure

Dr. Gosain is an Associate Editor of the Journal of Surgical Research; as such, he was excluded from the entire peer-review and editorial process for this manuscript.

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REFERENCES

1. Berger RP, Fromkin JB, Stutz H, et al. Abusive head trauma during a time of increased unemployment: a multicenter analysis. *Pediatrics*. 2011;128:637—643.
2. Huang MI, O'Riordan MA, Fitzenrider E, McDavid L, Cohen AR, Robinson S. Increased incidence of nonaccidental head trauma in infants associated with the economic recession. *J Neurosurg Pediatr*. 2011;8:171—176.
3. Raissian KM. Does unemployment affect child abuse rates? Evidence from New York State. *Child Abuse Negl*. 2015;48:1—12.
4. Wood JN, Medina SP, Feudtner C, et al. Local macroeconomic trends and hospital admissions for child abuse, 2000-2009. *Pediatrics*. 2012;130:e358—e364.
5. Berube A, Clement ME, Lafantaisie V, et al. How societal responses to COVID-19 could contribute to child neglect. *Child Abuse Negl*. 2020;116:104761.
6. Bradbury-Jones C, Isham L. The pandemic paradox: the consequences of COVID-19 on domestic violence. *J Clin Nurs*. 2020;29:2047—2049.
7. Evans ML, Lindauer M, Farrell ME. A pandemic within a pandemic - intimate partner violence during COVID-19. *N Engl J Med*. 2020;383:2302—2304.
8. Jetelina KK, Knell G, Molsberry RJ. Changes in intimate partner violence during the early stages of the COVID-19 pandemic in the USA. *Inj Prev*. 2020;27:93—97.
9. Sanford EL, Zagory J, Blackwell J-M, Szmuk P, Ryan M, Ambardekar A. Changes in pediatric trauma during COVID-19 stay-at-home epoch at a tertiary pediatric hospital. *J Pediatr Surg*. 2021;56:918—922.
10. Rapoport E, Reisert H, Schoeman E, Adesman A. Reporting of child maltreatment during the SARS-CoV-2 pandemic in New York city from March to May 2020. *Child Abuse Negl*. 2020;116:104719.
11. Kovler ML, Ziegfeld S, Ryan LM, et al. Increased proportion of physical child abuse injuries at a level I pediatric trauma center during the Covid-19 pandemic. *Child Abuse Negl*. 2020;116:104756.
12. Hector Linares G, Thomas W, Amber T, Sharmila D. Increase in child abuse injuries during the COVID-19 pandemic in west Texas. *Southwest Respir Crit Care Chron*. 2021;9:25—27.
13. Kaiser SV, Kornblith AE, Richardson T, et al. Emergency visits and hospitalizations for child abuse during the COVID-19 pandemic. *Pediatrics*. 2021;147. e2020038489.
14. Maassel NL, Asnes AG, Leventhal JM, Solomon DG. Hospital admissions for abusive head trauma at Children's hospitals during COVID-19. *Pediatrics*. 2021;148. e2021050361.
15. U.S. Economy at a glance. Available at: www.bls.gov/data/tables.htm. Accessed March 4, 2021.
16. Regions, states & areas at a glance. Available at: www.bls.gov/data/tables.htm. Accessed March 4, 2021.
17. Dow Jones industrial average historical data. Available at: https://finance.yahoo.com/quote/%5EDJI/history?p=%5EDJI. Accessed March 10, 2021.
18. R: a language and environmental for statistical computing. R Foundation for Statistical Computing. 2019. Available at: https://www.R-project.org/. Accessed May 18, 2021.
19. Bullinger LR, Boy A, Messner S, Self-Brown S. Pediatric emergency department visits due to child abuse and neglect following COVID-19 public health emergency declaration in the Southeastern United States. *BMC Pediatr*. 2021;21:401.
20. Barboza GE, Schiamberg LB, Pachl L. A spatiotemporal analysis of the impact of COVID-19 on child abuse and neglect in the city of Los Angeles, California. *Child Abuse Negl*. 2020;116:104740.
21. Matthay ZA, Kornblith AE, Matthay EC, et al. The DISTANCE study: determining the impact of social distancing on trauma epidemiology during the COVID-19 epidemic-An interrupted time-series analysis. *J Trauma Acute Care Surg*. 2021;90:700—707.
22. Shi Y, Kvasnovsky C, Khan S, et al. Impact of the COVID-19 pandemic on trauma activations at a pediatric level 1 trauma center in New York. *Pediatr Surg Int*. 2021;37:1409—1414.
23. Swedo E, Idaikkadar N, Leemis R, et al. Trends in U.S. Emergency department visits related to suspected or confirmed child abuse and neglect among children and adolescents aged <18 years before and during the COVID-19 pandemic — United States, January 2019—September 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:1841—1847.
24. De Boer C, Ghomrawi HM, Bouchard ME, Linton SC, Tian Y, Abdullah F. Effect of the COVID-19 pandemic on presentation and severity of traumatic injury due to physical child abuse across US children's hospitals. *J Pediatr Surg*. 2021;57:726—731.
25. Russell KW, Acker SN, Ignacio RC, et al. Child physical abuse and COVID-19: trends from nine pediatric trauma centers. *J Pediatr Surg*. 2022;57:297—301.
26. Taitz LS, King JM, Nicholson J, Kessel M. Unemployment and child abuse. *Br Med J (Clin Res Ed)*. 1987;294:1074—1076.
27. Gillham B, Tanner G, Cheyne B, Freeman I, Rooney M, Lambie A. Unemployment rates, single parent density, and indices of child poverty: their relationship to different categories of child abuse and neglect. *Child Abuse Negl*. 1998;22:79—90.
28. Klevens J, Schmidt B, Luo F, Xu L, Ports KA, Lee RD. Effect of the earned income tax credit on hospital admissions for pediatric abusive head trauma, 1995-2013. *Public Health Rep*. 2017;132:505—511.
29. Devries K, Knight L, Petzold M, et al. Who perpetrates violence against children? A systematic analysis of age-specific and sex-specific data. *BMJ Paediatr Open*. 2018;2:e000180.
30. Nguyen LH. Calculating the impact of COVID-19 pandemic on child abuse and neglect in the U.S. *Child Abuse Negl*. 2021;118:105136.
31. Escobar MA, Wallenstein KG, Christison-Lagay ER, Naiditch JA, Petty JK. Child abuse and the pediatric surgeon: a position statement from the trauma committee, the board of governors and the membership of the American pediatric surgical association. *J Pediatr Surg*. 2019;54:1277—1285.
32. Rosen NG, Escobar Jr MA, Brown CV, et al. Child physical abuse trauma evaluation and management: a Western Trauma Association and Pediatric Trauma Society critical decisions algorithm. *J Trauma Acute Care Surg*. 2021;90:641—651.