



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



## WPTC Papers

## Epidemiology of pediatric trauma during the coronavirus disease-2019 pandemic



Pradip P. Chaudhari<sup>a,b,\*</sup>, Melissa Anderson<sup>c</sup>, Shadassa Ourshalimian<sup>c</sup>, Catherine Goodhue<sup>c</sup>, Rasika Sudharshan<sup>b</sup>, Sara Valadez<sup>c</sup>, Ryan Spurrier<sup>b,c</sup>

<sup>a</sup> Division of Emergency and Transport Medicine, Department of Pediatrics, Children's Hospital Los Angeles, 4650 Sunset Blvd, Mail Stop 113, Los Angeles, CA 90027, USA

<sup>b</sup> Keck School of Medicine of the University of Southern California, 1975 Zonal Ave, Los Angeles, CA 90033, USA

<sup>c</sup> Division of Pediatric Surgery, Department of Surgery, Children's Hospital Los Angeles, 4650 Sunset Blvd, Los Angeles, CA 90027, USA

## ARTICLE INFO

## Article history:

Received 21 September 2021

Accepted 27 September 2021

## Keywords:

Pediatric trauma

COVID-19 pandemic

## ABSTRACT

**Background/purpose:** We aimed to describe the epidemiology of trauma activations and variations in injury patterns, injury severity, and hospital length-of-stay for injured children in Los Angeles (LA) County during the coronavirus-disease-19 (COVID-19) pandemic.

**Methods:** We conducted a retrospective cross-sectional study of children aged < 18-years evaluated in 15 trauma centers from 2019 to 2020 and entered in the LA County trauma registry. We defined 01/01/2019–03/18/2020 as pre-pandemic and 03/19/2020–12/31/2020 as the pandemic period. Our primary outcome was pediatric trauma activations. We analyzed demographic and clinical data, including types and severity of injuries sustained. We conducted unadjusted bivariate analyses of injury patterns between periods. Segmented linear regression models were used to test rates (per 100,000 LA County children) of trauma activations pre-pandemic versus the pandemic period.

**Results:** We studied 4399 children with trauma activations, 2695 of which occurred pre-pandemic and 1701 in the pandemic period. Motor vehicle collisions, gunshot wounds, and burns increased during the pandemic (all  $p$ -values < 0.05), while sports injuries decreased ( $p$  < 0.001). Median injury severity scores ( $p$  = 0.323) and Glasgow Coma Scales ( $p$  = 0.558) did not differ between periods, however mortality ( $p$  = 0.023) decreased during the pandemic. Segmented linear regression estimates demonstrated that rates of trauma activations pre-pandemic were similar to the pandemic period ( $p$  = 0.384).

**Conclusion:** Pediatric trauma activations in LA County did not significantly differ during the COVID-19 pandemic, but types and severity of injuries varied between pre-pandemic and pandemic periods. With lockdown restrictions being lifted and novel SARS-CoV-2 variants circulating, our investigation describes this recent epidemiologic phenomenon to aid future preparation for healthcare systems.

**Level of evidence:** Level III

**Type of study:** Retrospective cross-sectional study

© 2021 Elsevier Inc. All rights reserved.

**Abbreviations:** ACS, American College of Surgeons; AIS, Abbreviated Injury Scale; CDC, Centers for Disease Control and Prevention; CI, Confidence Interval; CT, Computed Tomography; COVID-19, Coronavirus Disease-2019; ED, Emergency Department; GCS, glasgow coma scale; ICU, Intensive Care Unit; ICD-10, International Classification of Disease Version 10; IQR, Interquartile Range; ITS, Interrupted Time Series; LA, Los Angeles; LOS, Length of Stay; MPH, Miles Per Hour; MVC, Motor Vehicle Collisions; OR, Odds Ratio; SARS-CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; TEMIS, Trauma and Emergency Medicine Information System; WHO, World Health Organization.

Previous communication: Podium presentation in the Scientific Abstract Session at the 2021 Western Pediatric Trauma Conference.

\* Corresponding author at: Division of Emergency and Transport Medicine, Children's Hospital Los Angeles, 4650 Sunset Blvd, Mail Stop 113, Los Angeles, CA 90027, USA.

E-mail address: [pchaudhari@chla.usc.edu](mailto:pchaudhari@chla.usc.edu) (P.P. Chaudhari).

## 1. Introduction

On March 11th, 2020, the World Health Organization (WHO) declared coronavirus disease-19 (COVID-19) a global pandemic. In response to the pandemic, the state of California issued a statewide stay-at-home order on March 19th, 2020. In 2020, Los Angeles (LA) County experienced a bimodal pandemic surge, which included a smaller surge of COVID-19 cases during the summer of 2020 as some lockdown restrictions were lifted, followed by a larger surge of cases in the late Fall of 2020.

The disease and the resultant lockdown measures significantly affected all aspects of the healthcare system. Overall pediatric emergency department (ED) visits declined significantly as the pandemic evolved [1–3]. Similarly, overall visits for injuries also declined [1,4,5] and single center reports describe similar declines

in pediatric trauma volumes during the pandemic [6–9]. The late 2020 surge in LA County significantly altered referral patterns and emergency medical services mandates for both medical and trauma patients within LA County because of the overwhelming effect of COVID-19 on the pre-hospital and hospital systems.

LA County, which contains over 2.1 million children, is serviced by 15 Level 1 and 2 trauma centers, including 1 American College of Surgeons (ACS)-verified Level 1 Pediatric Trauma Center. Although decreased rates of traumatic injuries have been previously reported during the pandemic [6–9], we observed stable trauma volumes at our pediatric trauma center. The unique epidemiology of pandemic surges experienced in LA County provided an opportunity to study the pandemic's effect on pediatric trauma volumes, injury patterns, and severity of traumatic injuries. With the lockdown restrictions being lifted in the Spring of 2021, and the potential for proliferation of novel circulating severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants, it is prudent to investigate this recent epidemiologic phenomenon for future preparation for pre-hospital and hospital systems.

We therefore aimed to describe the epidemiology of trauma activations for injured children in LA County. We hypothesized that the rate of pediatric trauma activations within LA County varied with California's statewide COVID-19 shelter-in-place policy and declined compared to the pre-pandemic period of 2019–2020. As a secondary objective, we aimed to describe variations in mechanism of injury, severity of injury, and hospital length-of-stay over the pre-pandemic to pandemic study period.

## 2. Materials and methods

### 2.1. Design, data source, and study population

We performed a retrospective multicenter cross-sectional database study. We included all children less than 18 years old who were evaluated in one of the 15 LA County ACS-verified trauma centers and subsequently entered in the LA County Trauma and Emergency Medicine Information System (TEMIS) trauma registry from January 1st, 2019 to December 31st, 2020. Of these 15 trauma centers, one is an ACS-verified Level 1 pediatric trauma center, and the remaining 14 centers are ACS-verified Level 1 or Level 2 adult trauma centers who also care for injured children. TEMIS data includes demographic and clinical data that are manually abstracted from the electronic health record at each trauma center. De-identified data are then entered into TEMIS by trained trauma registrars using standardized and established methods.

Epidemiologic COVID-19 data were downloaded from the LA County Department of Public Health website [10], which publishes mandatory reporting county-wide data on COVID-19 cases and deaths. Case data for the dashboard are obtained from the Confidentiality Morbidity Report, death data are obtained through routine death reporting surveillance, and testing data are obtained from the county electronic lab reporting system.

### 2.2. Measures of interest

Our primary outcome was pediatric trauma activations. Secondary outcomes were selected from demographic and clinical data, including types and severity of injuries sustained. We examined detailed mechanism of injury categories recorded in TEMIS, but also categorized these standard mechanism of injury codes into 6 categories, including (1) motor vehicle collisions (MVCs), (2) non-MVC injuries involving a vehicle, (3) Falls, (4) Assaults, (5) Self-Harm, and (6) Other. Injury severity score (ISS) was calculated using the maximum abbreviated injury scale (AIS) body region scores

and is based on standardized trauma-related *International Classification of Diseases Tenth Revision* (ICD-10) codes. Procedures performed were determined by ICD-10 codes and categorized as either operative (if performed in the operating room) or non-operative (if performed bedside).

MVCs were defined by principle mechanism of injury involving "ejected", "enclosed vehicle", "extricated", "survived fatal accident", "passenger space intrusion greater than 12 inches", "passenger space intrusion", "passenger space intrusion greater than 18 inches". Non-MVC injuries involving a vehicle included "impact more than 20 miles per hour (MPH)", "motorcycle or moped", "pedestrian or bike greater than 20 MPH", "pedestrian or bike less than 20 MPH". Falls included general injuries coded as a fall and any "fall greater than 15 feet". Assaults were defined as general assaults, "self-inflicted accidental", "stabbing", "gunshot wounds". Self-harm was a single separate category. Other category included a mechanism of injury corresponding to "unknown", "thermal burns", "other", "crush", "animal bite", and "sports/recreation".

We defined the pre-pandemic period as January 1, 2019–March 18th, 2020 and the pandemic period as March 19th, 2020–December 31st, 2020 based on the California statewide stay-at-home order declaration on March 19th, 2020.

### 2.3. Statistical analysis

We calculated frequencies and proportions for categorical variables and analyzed them with  $\chi^2$  tests of homogeneity. We described normally distributed continuous variables as means with standard deviations and analyzed them using the Student's t-test. We described non-normally distributed continuous variables as medians with interquartile ranges (IQR) and analyzed them with the Mann-Whitney U test. The assumptions underlying all statistical analyses were checked using graphical and numerical methods. Statistical significance was assigned at  $p < 0.05$ .

To test our primary hypothesis (that the rate of pediatric trauma activations within LA County varied with California's statewide COVID-19 shelter-in-place policy), we examined linear temporal trends in pediatric trauma activations, mechanism of injury, and all LA County COVID-19 cases. We examined trends in trauma activations and mechanism of injury as a rate per 100,000 children based on 2019 United States Census population estimates for LA County ( $N = 10,039,107$  total, of which 2,148,369 were estimated to be children < 18 years old) [11]. We analyzed rates of trauma activations before and after the COVID-19 shelter-in-place order, adjusting for seasonality and yearly trends. Models were based on time-series of monthly pediatric trauma activations in Los Angeles County from 2019 to 2020. We utilized standard methods for interrupted time-series (ITS) to assess the effects of the shelter-in-place order. The immediate effect of the order was modelled as a step function, including an indicator variable that changed in March 2020, while the gradual effects were studied with an interaction term between the effect of the order and time (month) [12,13]. Separate ITS segmented linear regression models were fit to test rates of trauma activations and different categories of mechanism of injury in the pre-pandemic versus pandemic period.

To investigate our secondary objective (to describe variations in mechanism of injury, severity of injury, and hospital length-of-stay), we conducted unadjusted bivariate analyses between pre-pandemic and pandemic periods. All data were analyzed using SAS® software 9.4 (copyright © 2016 SAS Institute Inc., Cary, NC). The study was approved by the attendant Institutional Review Board. We reported our findings in concordance the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies [14].

**Table 1**  
Patient and clinical characteristics, stratified by pre-pandemic and pandemic periods, of children < 18 years old who had a trauma activation in Los Angeles County Trauma Centers from 2019 to 2020.

Patient and Clinical Characteristics	Overall (n = 4396)	January 1, 2019-March 18th, 2020 Pre-Pandemic (n = 2695)	March 19th- December 31, 2020 Pandemic (n = 1701)	p-value
Age, years				0.0185
<1	372 (8.5)	245 (9.1)	127 (7.5)	
1–6	925 (21.0)	552 (20.5)	373 (21.9)	
7–15	1526 (34.7)	967 (35.9)	559 (32.9)	
16–18	1573 (35.8)	931 (34.6)	642 (37.7)	
Age, years (Mean, SD)	11.0 (SD, 6.3)	10.9 (SD, 6.2)	11.2 (6.3)	0.151
Female Sex	1458 (33.2)	910 (33.8)	548 (32.2)	0.2878
Race and/or ethnicity				0.0025
Non-Hispanic White	766 (17.4)	474 (17.6)	292 (17.2)	
Non-Hispanic Black	656 (14.9)	359 (13.3)	297 (17.5)	
Hispanic	2294 (52.2)	1433 (53.2)	861 (50.6)	
Other	680 (15.5)	429 (15.9)	251 (14.8)	
Injury Day of the Week				0.9509
Weekday	2937 (66.8)	1800 (66.8)	1137 (66.8)	
Weekend	1459 (33.2)	895 (33.2)	564 (33.2)	
Mechanism of Injury Categories				
MVC	854 (19.4)	496 (18.4)	358 (21.1)	0.031
Non-MVC injuries involving a vehicle	836 (19.0)	521 (19.3)	315 (18.5)	0.5032
Falls	1369 (31.1)	862 (32.0)	507 (29.8)	0.1286
Assaults	711 (16.2)	418 (15.5)	293 (17.2)	0.1326
Self-harm	13 (0.3)	5 (0.2)	8 (0.5)	0.0903
Other	613 (13.9)	393 (14.6)	220 (12.9)	0.1242

Values in table represent frequency (column percent) or mean (standard deviation). MVC, motor vehicle collision; SD, standard deviation.

**Table 2**  
Monthly Los Angeles County pediatric trauma activations, 2019 versus 2020.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<b>2019</b>	132 (5.8)	146 (6.5)	205 (9.1)	184 (8.1)	212 (9.4)	214 (9.5)	200 (8.8)	203 (9.0)	241 (10.7)	181 (8.0)	189 (8.4)	153 (6.8)	2260
<b>2020</b>	165 (7.7)	174 (8.1)	153 (7.2)	134 (6.3)	177 (8.3)	195 (9.1)	202 (9.5)	199 (9.3)	183 (8.6)	186 (8.7)	195 (9.1)	172 (8.1)	2135
<b>Total 2019 and 2020</b>	297 (6.8)	320 (7.3)	358 (8.1)	318 (7.2)	389 (8.9)	409 (9.3)	402 (9.1)	402 (9.1)	424 (9.6)	367 (8.4)	384 (8.7)	325 (7.4)	4395
<b>%Change 2020 versus 2019</b>	32.30%	26.20%	-21.0%	-22.1%	-11.6%	-3.50%	6.90%	3.80%	-19.6%	8.80%	9.20%	19.00%	

Values in parentheses are proportions of row totals.

### 3. Results

#### 3.1. Study sample characteristics

During the study period, 4407 children with trauma activations were identified in TEMIS. We excluded 11 children because of missing data (3 for missing principle mechanism of injury, 5 for missing sex, and 3 for missing injury date). After excluding cases based on missing data, 4396 children constituted the study sample. There were 2695 pediatric trauma activations in the pre-pandemic period from January 1st, 2019 to March 18th, 2020 and 1701 in the pandemic period from March 19th to December 31st, 2020 (Table 1). There were few differences in patient characteristics between pre- and pandemic periods. Race and/or ethnicity varied between periods with slightly more trauma activations occurring in non-Hispanic Black children during the pandemic (13.3% versus 17.5%,  $p \leq 0.05$ ). Mean age at time of injury presentation did not vary between pre-pandemic and pandemic periods ( $p = 0.15$ ).

#### 3.2. Temporal trends in trauma activations and COVID-19

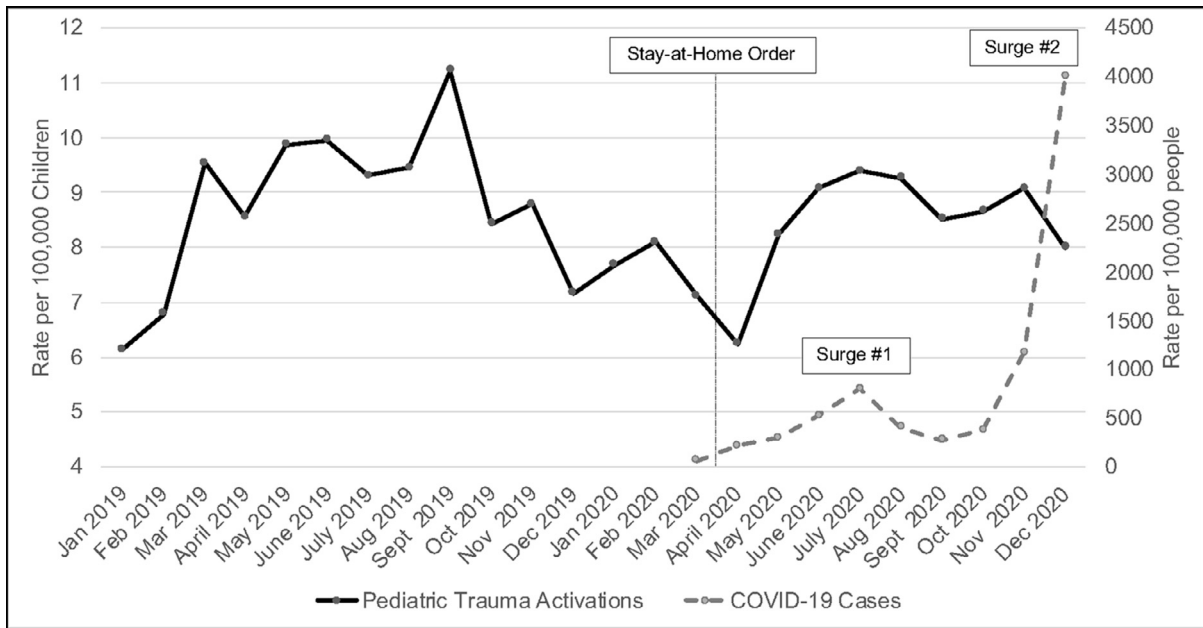
Linear temporal trends in rate of pediatric trauma activations per 100,000 children and all (adults and children) COVID-19 cases and COVID-19 deaths (per 100,000 persons) in LA County are displayed in Fig. 1 and Supplemental Figure. COVID-19 cases and deaths in LA County displayed a bi-modal distribution, with two primary surges, a smaller surge in Summer 2020 and a larger surge in the late Fall 2020. Rates of monthly trauma activations differed

between 2019 and 2020 (Table 2), with higher trauma activation rates during the two 2020 surges when compared to the previous year.

In our segmented linear regression model, overall, we found the rate of pediatric trauma activations during the pre-pandemic period did not significantly change (rate 0.03 per 100,000 children per month;  $p = 0.753$ ). In the first month after the stay-at-home order was instituted, there was no statistically significant change in activations (rate of -1.39 per 100,000 children;  $p = 0.207$ ). Thereafter, the pandemic pediatric trauma activation rate per 100,000 children also did not significantly change (rate 0.144 per 100,000 children;  $p = 0.384$ ). Similarly, evaluating rates for MVCs, Falls, Assaults, Self-harm, and other mechanisms of injury by ITS did not demonstrate statistically significant differences between pre- and pandemic periods. However, for Non-MVC injuries involving a vehicle rates were increasing pre-pandemic (rate 0.05 per 100,000 children per month;  $p = 0.009$ ). Immediately following the stay-at-home order there was a significant decrease in the rate (-0.58 per 100,000 children). However, the downward trend of this mechanism of injury during the pandemic did not persist (rate -0.02 per 100,000 children;  $p = 0.563$ ).

#### 3.3. Mechanism of injury, severity of injury, and hospital length-of-stay

The 4 most common mechanism of injury categories included MVCs, non-MVC injuries involving a vehicle, falls, and assaults (Table 1). Monthly rates (per 100,000 children in LA County) of



**Fig. 1.** Monthly Los Angeles County pediatric trauma activations (rate per 100,000 children in Los Angeles County) and COVID-19 cases (rate per 100,000 people in Los Angeles County), 2019–2020.

**Table 3**

Mechanism of injury sub-categories, stratified by pre-pandemic and pandemic periods, of children < 18 years old who had a trauma activation in Los Angeles County Trauma Centers from 2019 to 2020.

Mechanism of Injury	January 1, 2019-March 18th, 2020 Pre-Pandemic (n = 2695)	March 19th-December 31, 2020 Pandemic (n = 1701)	p-value
Motorized Vehicle			
MVC	367 (13.6)	269 (15.8)	0.044
MVC > 20 MPH	65 (2.4)	64 (3.8)	0.01
Extricated after MVC	24 (0.9)	6 (0.4)	0.035
Ejected after MVC	17 (0.6)	18 (1.1)	0.12
MVC with Passenger Space Intrusion	22 (0.8)	21 (1.2)	0.17
MVC with Passenger Space Intrusion 13–17 inches	41 (1.5)	28 (1.7)	0.746
MVC with Passenger Space Intrusion > 18 inches	17 (0.6)	10 (0.6)	0.859
Survived Fatal MVC	8 (0.3)	6 (0.4)	0.749
Motorcycle / Moped	30 (1.1)	41 (2.4)	0.001
Falls	778 (28.9)	467 (27.5)	0.311
Fall > 15 feet	84 (3.1)	40 (2.4)	0.136
Pedestrian / Bicycle < 20 MPH	163 (6.1)	87 (5.1)	0.193
Pedestrian / Bicycle > 20 MPH	263 (9.8)	123 (7.2)	0.004
Assault	105 (3.9)	42 (2.5)	0.01
Gunshot Wound	202 (7.5)	178 (10.5)	0.001
Stabbing	92 (3.4)	54 (3.2)	0.667
Self-inflicted Accidental	19 (0.7)	19 (1.1)	0.151
Self-Inflicted Intentional	5 (0.2)	8 (0.5)	0.09
Crush	19 (0.7)	8 (0.5)	0.332
Thermal Burn	31 (1.2)	52 (3.1)	<0.001
Sports / Recreation	152 (5.6)	25 (1.5)	<0.001
Animal Bite	42 (1.6)	40 (2.4)	0.058
Other Mechanism of Injury	123 (4.6)	77 (4.5)	0.954
Unknown Mechanism of Injury	26 (1.0)	18 (1.1)	0.762

Values in table represent frequency (column percent). MVC, motor vehicle collision; MPH, miles per hour.

these mechanisms from 2019 to 2020 are displayed in Fig. 2. More detailed mechanism of injury sub-categories are outlined in Table 3 and compared between pre-pandemic and pandemic periods. Rates of both overall MVCs ( $p = 0.044$ ) and MVCs > 20 MPH ( $p = 0.010$ ) increased during the pandemic. Additionally, gunshot wounds ( $p = 0.001$ ) and burns ( $p < 0.001$ ) increased during the pandemic, while assaults ( $p = 0.010$ ) and sports and recreational injuries ( $p < 0.001$ ) decreased.

Severity of injury and hospital length-of-stay data is outlined in Table 4. Although there were no significant differences in median ISS ( $p = 0.323$ ) and Glasgow Coma Scale (GCS) ( $p = 0.558$ ) between pre-pandemic and pandemic periods, intubations ( $p < 0.001$ ) and mortality ( $p = 0.023$ ) decreased during the pandemic. Hospitalization and intensive care unit (ICU) rates and lengths of stay (LOS) were similar between pre-pandemic and pandemic periods (Table 4). Trauma transfers from a non-trauma

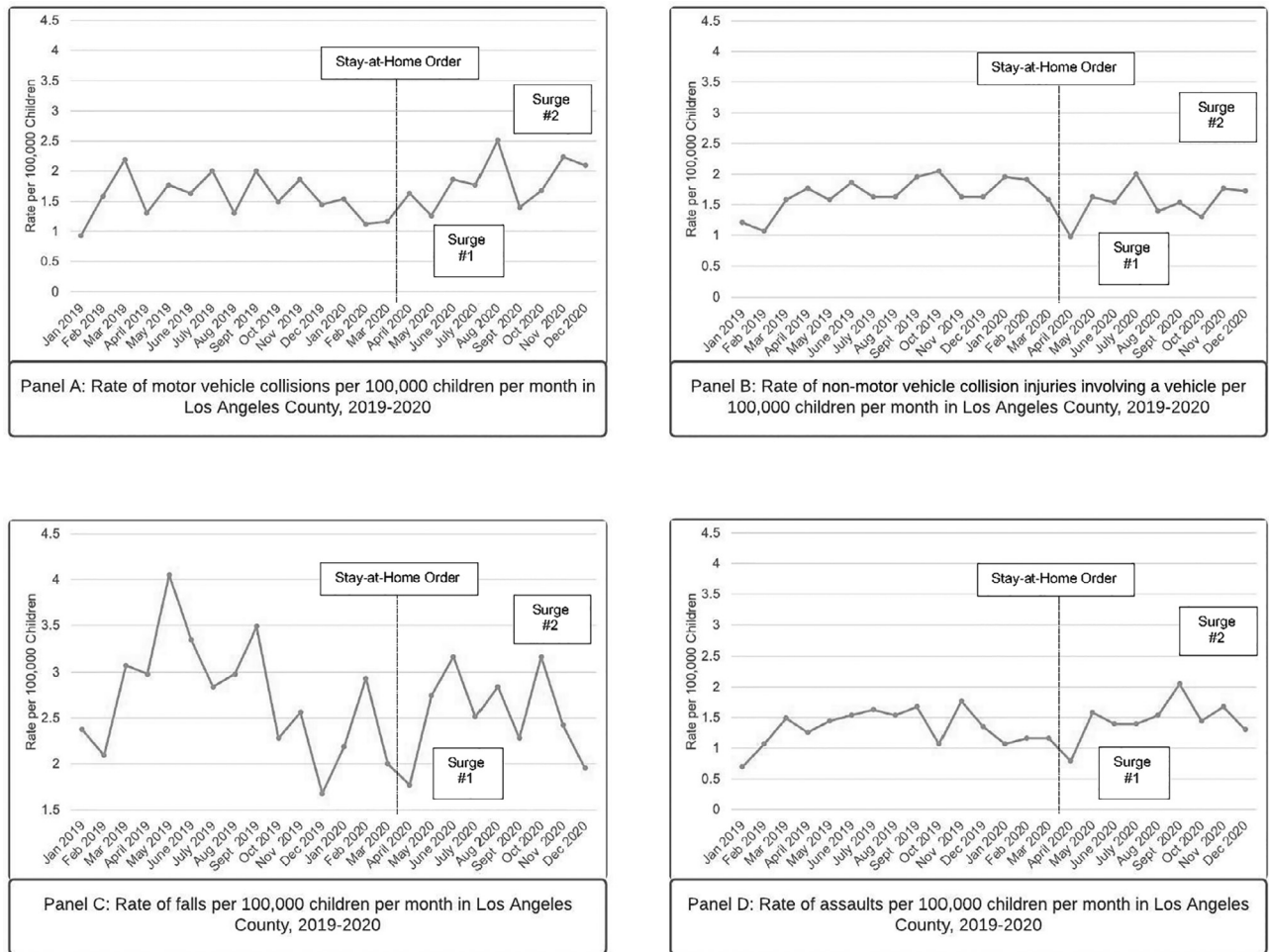


Fig. 2. Monthly mechanism of injury rates (per 100,000 children in Los Angeles County), 2019–2020.

Table 4

Clinical markers of severity and resource utilization data, stratified by pre-pandemic and pandemic periods, of children < 18 years old who had a trauma activation in Los Angeles County Trauma Centers from 2019 to 2020.

	Overall (n = 4396)	January 1, 2019–March 18th, 2020 Pre-Pandemic (n = 2695)	March 19th–December 31, 2020 Pandemic (n = 1701)	Percent Difference <sup>a</sup>	p-value
Injury Severity Score [median, IQR]	5 [2.0, 10.0]	5 [3.0, 10.0]	5 [2.0–10.0]	0.0%	0.323
Glasgow Coma Scale [median, IQR]	15 [15.0, 15.0]	15 [15.0, 15.0]	15 [15.0, 15.0]	0.0%	0.558
Procedure performed	2018 (45.9)	1163 (43.2)	855 (50.3)	7.1%	< 0.001
Non-operative procedure	1278 (63.3)	737 (63.4)	541 (63.3)	−0.1%	0.965
Operative procedure	740 (36.7)	426 (36.6)	314 (36.7)	0.1%	
Intubated	193 (9.6)	135 (11.6)	58 (6.8)	−4.8%	< 0.001
Discharged from ED	1653 (37.6)	1013 (37.6)	640 (37.6)	0.0%	0.980
Monthly percent discharged from ED (mean, SD)	37.7 (SD, 3.2)	37.7 (SD, 3.3)	37.8 (SD, 3.2)	0.1%	0.978
Hospitalized	2737 (62.3)	1682 (62.4)	1055 (62)	−0.4%	0.795
Monthly percent hospitalized (mean, SD)	62.1 (SD, 3.1)	62.3 (SD, 3.3)	61.8 (SD, 3.0)	−0.5%	0.934
ICU	1029 (23.4)	633 (23.5)	396 (23.3)	−0.2%	0.874
Mortality					0.023 <sup>b</sup>
Unknown	10 (0.2)	0 (0)	10 (0.6)	0.6%	
Died	122 (2.8)	87 (3.2)	35 (2.1)	−1.1%	
Lived	4264 (97)	2608 (97.8)	1656 (97.4)	−0.4%	
ED LOS, hours [median, IQR]	4.1 [3.0, 6.6]	4.1 [2.9, 6.2]	4.5 [3.0, 7.0]	0.4%	< 0.001
ICU LOS, days [median, IQR]	3 [2.0, 4.0]	3 [2.0, 4.0]	3 [2.0, 5.0]	0.0%	0.846
Hospital LOS, days [median, IQR]	2 [1.0, 4.0]	2 [1.0, 4.0]	2 [1.0, 4.0]	0.0%	0.157
Trauma transfer	3438 (78.2)	2080 (77.2)	1358 (79.8)	2.6%	0.038

<sup>a</sup> pandemic minus pre-pandemic periods.

<sup>b</sup> excluding unknown. Values in table represent frequency (column percent). ED, emergency department; interquartile range, IQR; intensive care unit, ICU; length of stay, LOS; standard deviation, SD.

center to a trauma center increased during the pandemic period ( $p = 0.038$ ).

#### 4. Discussion

In our large sample of pediatric trauma activations in LA County from 2019 to 2020, we found alterations in pediatric trauma trends, injury patterns, and injury severity during the COVID-19 pandemic. Interestingly, pediatric trauma activations increased during the bimodal LA County COVID-19 surges, although overall trauma activations did not differ between pre-pandemic and pandemic periods. We found differences in types of injuries between the two periods. Following the stay-at-home order, MVCs, gunshot wounds, and burns increased, while sports and recreational injuries decreased. Overall injury severity scores and hospital length-of-stay did not differ between the two periods, but less children died during the pandemic from trauma than in the previous year.

Although some reports have described decreases in pediatric trauma volumes during the COVID-19 pandemic [6–9,15], we found overall rates of pediatric trauma activations in LA County did not change significantly compared to the pre-pandemic period. After the California statewide stay-at-home order on March 19th, 2020, in LA County there were 3 additional dates in 2020 when pandemic control measures were substantially changed. On June 7th, 2020 county-wide lockdown restrictions were partially lifted, with non-essential businesses allowed to reopen with partial restrictions. On July 12th, 2020, because of increasing COVID-19 cases, partial restrictions were reinstated, with non-essential businesses being partially closed or recommended to close until November 22nd, 2020, when a county-wide strict lockdown was reinstated in response to a large surge of COVID-19 cases. The strict lockdown remained in effect until Spring of 2021. Relatedly, LA County experienced two primary COVID-19 surges, a smaller surge in Summer 2020 and a larger surge in the late Fall 2020. Although we expected lower trauma volumes during the surges in response to COVID-19 circulation in the community, we found the inverse, with trauma volumes increasing during these surges. This finding may be a result of less quarantining during periods of “COVID fatigue”, which some suggest may be partially responsible for local surges experienced during the prolonged pandemic. Additionally, geographic differences likely contribute to differences we observed compared to previous reports. Given the unique challenges experienced by quarantining and the presumed decreased transmission of SARS-CoV-2 in outdoor environments, the warmer climate in LA County may have resulted in more people outside, and therefore more at risk for traumatic injuries, during the pandemic than in previous years.

We found that rates of MVCs and higher speed MVCs increased in the pandemic period, which may be secondary to less traffic in LA County during the pandemic [16] resulting in higher than usual vehicle speeds [17]. However, this finding did not translate into higher injury severity scores in the sample, as measured by ISS and GCS, or by mortality and intubation rates, which decreased significantly. We found that the number of children who sustained firearm injuries increased in the pandemic period, similar to the findings of Cohen et al. [18]. ED, hospital, and ICU lengths of stay remained similar between pre-pandemic and pandemic periods, suggesting no large-scale differences in injury severity between the two periods. The late Fall 2020 COVID-19 pandemic surge in LA County resulted in alterations of emergency medical services mandates for scene to facility and interfacility transfers. Relatedly, we found significant differences in rates of trauma transfers from non-trauma centers to trauma centers between pre-pandemic and pandemic periods, likely because of COVID-19 volume related changes in pre-hospital and hospital referrals.

Our investigation has several important limitations. We leveraged a large clinical trauma database, which allows for a high-level examination of trends and variation in clinical and hospital length-of-stay data but does not allow detailed patient-level review for specific clinical characteristics. In order to examine high-level trends in injury patterns, we recategorized detailed mechanisms of injuries into larger categories, which may have resulted in loss of granular data on injury patterns. Additionally, COVID-19 case ascertainment varied over time because of testing capabilities within the county, however we found the trend in COVID-19 cases was similar to the trend in COVID-19 deaths. We recognize that our analysis of trend of rates of pediatric trauma activations in our cohort only without a control group is less robust as it does not account for other events that may have influenced the outcome and that may have occurred at the same time as the intervention. However, level and trend of the pre-pandemic segment acts as a control for the pandemic segment and single group time series are a methodologically acceptable design for studying pre/post effects. This database only includes trauma activations captured by hospital trauma registrars, and thus may not include some patients with trauma who were not documented as such or those who did not present to the ED for evaluation. However, because of ACS requirements for standardization and data capture of trauma patients meeting activation criteria, we believe that most children with moderate to severe trauma in LA County are captured in TEMIS, and that if children were not included in TEMIS, it would be children with more minor trauma. Because of limitations of the dataset, we were not able to easily identify if injuries were secondary to child physical abuse and were therefore unable to analyze rates of child abuse in this sample. Our sample represents children at trauma centers in LA County, and our results might not be generalizable to other settings.

#### 5. Conclusion

We found alterations in pediatric trauma activations, mechanism of injury patterns, and severity of injury in LA County during the COVID-19 pandemic. Overall pediatric trauma activations did not significantly change, but types and severity of injuries were impacted following the stay-at-home order. With lockdown restrictions being lifted in many areas of the country during traditionally higher trauma volume months and the potential for proliferation of circulating novel SARS-CoV-2 variants, our investigation describes an important phenomenon that may aid pre-hospital and hospital systems in preparing for future public health crises.

#### Financial support statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

#### Declaration of Competing Interest

None

#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.jpedsurg.2021.09.054](https://doi.org/10.1016/j.jpedsurg.2021.09.054).

#### References

- [1] DeLaroche AM, Rodean J, Aronson PL, Fleegler EW, Florin TA, Goyal M, et al. Pediatric emergency department visits at US children's hospitals during the COVID-19 pandemic. *Pediatrics* 2020:e2020039628. doi:[10.1542/peds.2020-039628](https://doi.org/10.1542/peds.2020-039628).

- [2] Kruizinga MD, Peeters D, van Veen M, van Houten M, Wieringa J, Noordzij JG, et al. The impact of lockdown on pediatric ED visits and hospital admissions during the COVID-19 pandemic: a multicenter analysis and review of the literature. *Eur J Pediatr* 2021. doi:10.1007/s00431-021-04015-0.
- [3] Silvagni D, Baggio L, Lo Tartaro Meragliotta P, Soloni P, La Fauci G, Bovo C, et al. Neonatal and pediatric emergency room visits in a tertiary center during the COVID-19 pandemic in Italy. *Pediatr Rep* 2021;13:168–76. doi:10.3390/pediatric13020023.
- [4] Christey G, Amey J, Campbell A, Smith A. Variation in volumes and characteristics of trauma patients admitted to a level one trauma center during national level 4 lockdown for COVID-19 in New Zealand. *N Z Med J* 2020;133:81–8.
- [5] Baxter I, Hancock G, Clark M, Hampton M, Fishlock A, Widnall J, et al. Paediatric orthopaedics in lockdown. *Bone Jt Open* 2020;1:424–30. doi:10.1302/2633-1462.17.BJO-2020-0086.R1.
- [6] Sanford EL, Zagory J, Blackwell J, 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. doi:10.1016/j.jpedsurg.2021.01.020.
- [7] Rougereau G, Guedj R, Irtan S, Qasemyar Q, Vialle R, Langlais T. Emergency department visits for pediatric traumatic injuries during general confinement: a single-center study in an urban setting. *Arch Pédiatri* 2021;2–4. doi:10.1016/j.arcped.2021.02.012.
- [8] Kamine TH, Rembisz A, Barron RJ, Baldwin C, Kromer M. Decrease in trauma admissions with COVID-19 pandemic. *West J Emerg Med* 2020;21:819–22. doi:10.5811/westjem.2020.5.47780.
- [9] Sheridan GA, Nagle M, Russell S, Varghese S, O'Loughlin PF, Boran S, et al. Pediatric trauma and the COVID-19 pandemic: a 12-Year comparison in a level-1 trauma center. *HSS J* 2020;16:92–6. doi:10.1007/s11420-020-09807-y.
- [10] Los Angeles County department of public health. LA County COVID-19 surveillance dashboard. Accessed May 4, 2021. [http://dashboard.publichealth.lacounty.gov/covid19\\_surveillance\\_dashboard/](http://dashboard.publichealth.lacounty.gov/covid19_surveillance_dashboard/)
- [11] U.S. Census Bureau. The census bureau's population estimates program (PEP). Published 2019. Accessed May 4, 2021. <https://www.census.gov/quickfacts/losangelesciticifornia>.
- [12] Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther* 2002;27:299–309. doi:10.1046/j.1365-2710.2002.00430.x.
- [13] Cook TD, Campbell DT. *Quasi-experimentation: design & analysis issues for field setting*. Boston, MA: Houghton Mifflin Company; 1979.
- [14] Vandembroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. *PLOS Med* 2007;4:e297. doi:10.1371/journal.pmed.0040297.
- [15] Matthey ZA, Kornblith AE, Matthey EC, Sedaghati M, Peterson S, Boeck M, 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;90:700–7. doi:10.1097/TA.0000000000003044.
- [16] Stavrinou D, McManus B, Mrug S, He H, Gresham B, Albright MG, et al. Adolescent driving behavior before and during restrictions related to COVID-19. *Accid Anal Prev* 2020;144:105686. doi:10.1016/j.aap.2020.105686.
- [17] Katrakazas C, Michelaraki E, Sekadakis M, Yannis G. A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety. *Transp Res Interdiscip Perspect* 2020;7:100186. doi:10.1016/j.trip.2020.100186.
- [18] Cohen JS, Donnelly K, Patel SJ, Badolato GM, Boyle MD, McCarter R, et al. Firearms injuries involving young children in the United States during the COVID-19 pandemic. *Pediatrics* 2021:e2020042697. doi:10.1542/peds.2020-042697.