

The impact of COVID-19 pandemic on traumatic injuries in children: a longitudinal observational study

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Abstract

The COVID-19 pandemic affected pediatric emergency department (ED) visits for traumatic injuries. This retrospective study analyzed data from Merano Hospital, Italy, spanning January 2018 to October 2022, focusing on standardized ED visits per 1000 orthopedic attendances. Findings indicated a significant decline in ED visits at the pandemic's onset (March 2020), followed by a gradual increase until April 2022, when emergency measures ended. Fracture and orthopedic procedure rates remained stable, while dislocations saw a temporary increase, then declined significantly. Overall, the pandemic's influence on pediatric trauma was minimal, with ED visits and injury patterns returning to pre-pandemic levels. These findings suggest that pandemic-related restrictions, including reduced outdoor activities and fewer traffic accidents, may have temporarily modified injury risk factors.

Introduction

Trauma remains the leading cause of morbidity and mortality in children, frequently stemming from accidents at home, play, sports, or traffic incidents.^{1,2} The COVID-19 pandemic notably impacted healthcare systems and societal behaviors, affecting pediatric trauma incidences, as well as having an impact on the Emergency Department (ED) system in general.^{3,5} While some studies indicated a decline in pediatric injuries, such as in New Zealand,⁶ others, like a UK study, reported an increase in brain trauma linked to abuse during the pandemic.⁷ In the U.S., overall pediatric injuries decreased, but with rises in specific cases such as burns and penetrating injuries.⁶ The full extent of the pandemic's impact on pediatric ED visits remains unclear, necessitating accurate analysis for timely diagnosis and treatment.^{1,6,8} Pandemic-related factors like lockdowns and reduced ED visits may have influenced trauma risk and attendance rates.⁹⁻¹¹ This study aims to evaluate changes in ED attendances for pediatric trauma during pre- and post-pandemic periods to inform health policy and child safety strategies.

Materials and Methods

Study design and setting

This retrospective study included children aged 1-14 years visiting the ED at Merano General Hospital, Italy, between January 2018 and October 2022. This hospital, located in a high-tourism

Alpine area with around 100,000 residents, prioritizes patients using the Manchester Triage System (MTS). Pediatric patients with orthopedic issues are assessed in the ED's orthopedic section, while severe trauma cases are handled by other specialists. Data from all ED attendances are digitally recorded, capturing details like triage codes, treatments, and outcomes.

During the pandemic, the ED remained fully operational. From March to April 2020, the hospital served as the COVID-19 referral center for South Tyrol, subsequently rotating COVID-19 patients with other regional hospitals between November 2020 and June 2021.

Patients and data collection

Data were extracted for children presenting with orthopedic complaints or traumatic injuries. The data were extracted from the anonymized emergency department database. Excluded were those under one year, with isolated head or thoracic injuries, or with life-threatening trauma, as these cases bypass the orthopedic section. We collected demographic and clinical data, including age, visit date, weekday/weekend arrival, time of day, MTS code, disposition (hospitalization, discharge, or left ED), and presence of fractures or dislocations.

ED attendances for traumatic injuries were standardized to total attendances to the ED orthopedic section using the following formula:

$$STD\ variable = \left(\frac{variable}{number\ of\ attendances\ per\ month} \right) \times 1000$$

Standardization was applied to ED attendances to account for monthly variations across pandemic phases, aligning with previous methodologies.^{3,12,13}

Statistical analysis

Categorical variables were summarized as counts and percent-

ages, while continuous variables were described as mean and Standard Deviation (SD) or median with Interquartile Range (IQR), depending on distribution. Univariate comparisons used Chi-square, Student's t-test, or Mann-Whitney test. Interrupted Time-Series Analysis (ITSA) evaluated the impact of COVID-19 on pediatric ED visits, comparing pre-pandemic (January 2018 to February 2020) with post-pandemic (March 2020 to October 2022) trends. Analyses used STATA 16.0, with significance at $p < 0.05$.

Ethical consideration

The study was conducted in accordance with local ethics committees (Ethics Committee for Clinical Research, South Tyrol Health Authority, Bolzano, Italy, approval number 84-2022) and was conducted according to the Declaration of Helsinki principles for ethical medical research involving human subjects. Since the study is retrospective and based on an anonymized database, informed consent for participation in the study was not required.

Results

Between January 2018 and October 2022, 79,114 patients attended the Emergency Department (ED) for traumatic injuries, of whom 10,285 were children aged 1 to 14 years, meeting the study's inclusion criteria. The yearly distribution of pediatric attendances is detailed in *Supplementary materials, Table 1*. In 2018, these cases accounted for 13.8% (2,653/19,167) of all ED orthopedic attendances, decreasing to 11.6% (1,437/12,307) in 2020, before rising to 13.3% (1,987/14,948) by 2022. The overall trend for pediatric and adult ED attendances is shown in Figure 1.

Of the 10,285 children, 4.1% experienced dislocations, 25.2% sustained fractures, and 1.9% required hospitalization for orthopedic procedures, with 7.7% of fractures needing surgery (Table 1). The average age of pediatric patients was 9.4 years, with most attending on weekdays (73.4%) and during daytime hours (88.9%).

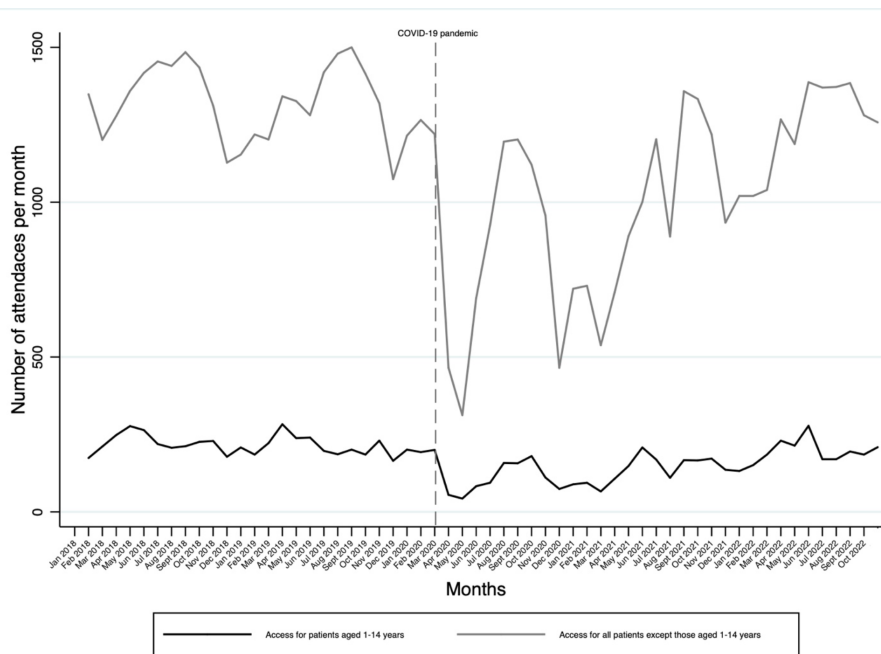


Figure 1. Number of attendances to the ED orthopedic section for traumatic injuries divided by month and according to patient age (patients aged 1-14 versus all other age groups).

A majority received non-urgent green triage codes and were brought to the ED in private vehicles.

The characteristics of ED attendances were categorized into pre-pandemic, pandemic, and post-pandemic periods (Table 1). There were statistically significant variations in patient age

($p < 0.001$), weekday versus weekend attendances, and triage code distribution ($p < 0.001$) across these periods. Notably, urgent cases decreased and non-urgent cases increased during the pandemic.

ITSA results, depicted in Figure 2 and detailed in *Supplementary materials, Table 2*, show that standardized ED

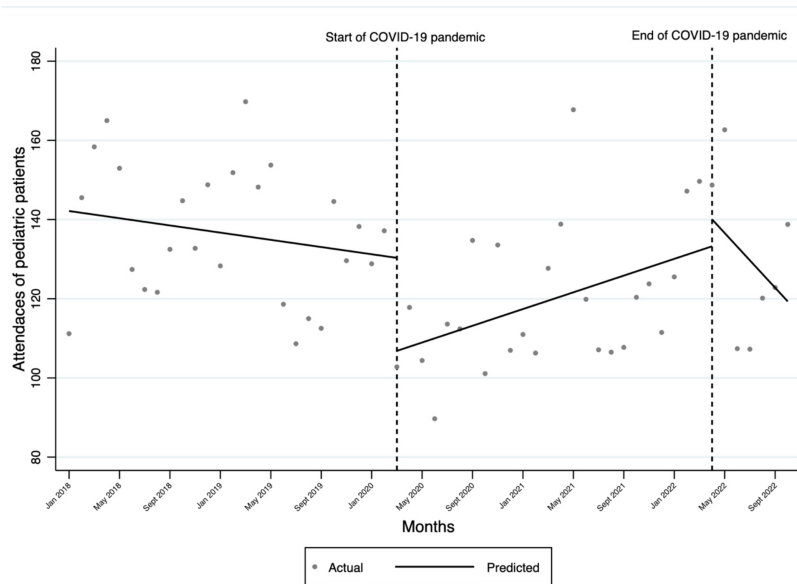


Figure 2. Interrupted time series analysis assessing the rate of pediatric patients with traumatic or orthopaedic problems per 1,000 attendances to the ED orthopaedic section per month.

Table 1. Characteristics of included patients and comparison of patient characteristics before and after the outbreak of COVID-19 pandemic (March 2020).

Variables	Total study population	Pre COVID-19 period (Until February 2020)	Post COVID-19 period (After March 2020)	p ^a
Patients, n (%)	10,285 (100)	5742 (55.8)	4543 (44.2)	
Age, year, mean (SD)	9.4 (3.5)	9.2 (3.6)	9.6 (3.4)	<0.001
Day of arrival, n (%)				0.805
Weekday (Mon-Fri)	7549 (73.4)	4220 (73.4)	3329 (73.2)	
Weekend (Sat-Sun)	2736 (26.6)	1522 (26.5)	1214 (26.7)	
Time of arrival, n (%)				0.006
Day (8 a.m. - 8 p.m.)	9139 (88.9)	5146 (89.6)	3993 (87.9)	
Night (8 p.m. - 8 a.m.)	1146 (11.1)	596 (10.3)	550 (12.1)	
Mode of arrival to the ED, n (%)				0.452
Private vehicle	9537 (92.7)	5313 (92.5)	4224 (92.9)	
Ambulance	679 (6.6)	393 (6.8)	286 (6.3)	
Emergency physician/helicopter	69 (0.7)	36 (0.7)	33 (0.8)	
MTS code, n (%)				<0.001
Blue	190 (1.8)	35 (0.6)	155 (3.4)	
Green	7600 (73.9)	4026 (70.1)	3574 (78.7)	
Yellow	2434 (23.6)	1635 (28.4)	799 (17.6)	
Orange	60 (0.7)	45 (0.8)	15 (0.3)	
Red	1 (0.0)	1 (0.0)	0 (0.0)	
Dislocations, n (%)	420 (4.1)	239 (4.1)	181 (3.9)	0.688
Fractures, n (%)	2593 (25.2)	1424 (24.8)	1169 (25.7)	0.283
Fractures requiring orthopaedic operation, n (%)	200 (1.9)	108 (1.8)	92 (2.0)	0.615
Outcome, n (%)				<0.001
Patient leaves ED without medical evaluation	197 (1.9)	143 (2.5)	54 (1.2)	
Patient discharged	9807 (95.3)	5443 (94.8)	4364 (96.0)	
Patient hospitalized	281 (2.8)	156 (2.7)	125 (2.8)	

ED, Emergency Department; MTS, Manchester Triage System; SD, Standard Deviation; ^aCategorical variables were compared with a chi-square test. When more categories are present, the chi-squared test can detect differences across multiple levels. In this case, the p-value tells if there is an overall association between the variables, but it does not specify which categories are different from each other.

attendances for pediatric traumatic injuries significantly decreased at the pandemic's onset in March 2020 (-23.49/1000; 95% CI: -40.29 to -6.66; $p=0.007$), followed by a gradual recovery up to April 2022 (1.51/1000; 95% CI: 0.22 to 2.79; $p=0.022$). Fracture and orthopedic procedure rates remained stable post-pandemic (*Supplementary materials, Table 3*). A non-significant increase in dislocations occurred in March 2020, followed by a significant monthly decrease (-0.19/1000; $p=0.006$), as shown in *Supplementary Materials, Figure 1*.

After April 2022, ED attendances, fractures, dislocations, and surgical interventions returned to pre-pandemic levels. Although overall trends normalized, the pandemic prompted significant shifts in pediatric trauma visits, highlighting its impact on healthcare-seeking behaviors. Ongoing monitoring of ED utilization patterns may inform future strategies for managing pediatric trauma care during public health crises.

Discussion

Our study utilized ITSA over a prolonged period to assess the impact of the COVID-19 pandemic on pediatric ED attendances for trauma, revealing initial changes followed by a return to pre-pandemic levels. Unlike the general reduction in ED visits reported elsewhere, such as the 41.5%-63.5% decrease in U.S. ED attendances noted by Jeffrey *et al.* and the 70% reduction for non-COVID-19 cases described by Santi *et al.*, our findings indicate that fracture incidence among children remained stable despite decreased ED usage.¹⁴⁻¹⁶

Studies on pediatric trauma during the pandemic present mixed outcomes. For instance, Sullivan *et al.* reported a post-pandemic increase in pediatric trauma, while Harthi *et al.* found a decrease in ED visits for traumatic injuries.¹⁷⁻¹⁸ Our study contributes by standardizing pediatric trauma incidences, adjusting for fluctuating ED attendances, which provides a more accurate reflection of the pandemic's impact on pediatric trauma.

Fracture rates remained steady when standardized per 1000 attendances, suggesting that while overall ED attendance declined, fractures remained relatively constant. This trend may be attributed to reduced outdoor activity during lockdowns, which minimized injury risks from activities like sports and road accidents, as indicated by Keys *et al.* who reported a significant drop in pediatric road accident injuries during the pandemic.¹⁹ Consequently, pandemic-related restrictions likely mitigated some trauma risk factors but had minimal effect on those occurring in domestic settings.

Interestingly, our study identified a transient increase in limb dislocations in March 2020, with rates later reverting to pre-pandemic levels. Existing research on dislocations during the pandemic is limited, with only one study comparing trauma types before and after the pandemic, reporting fewer dislocations post-pandemic but lacking standardization, which limits interpretability.¹⁹ Our data suggest an initial rise in dislocations due to domestic incidents during lockdowns, as potential exposures to trauma shifted indoors. However, without granular detail on injury contexts, a definitive link between dislocation trends and domestic violence or other specific causes remains speculative.

Our study also observed significant shifts in triage prioritization during the pandemic, with an increase in non-urgent (blue and green) codes. This change aligns with previous studies that noted a rise in ED visits for less urgent conditions post-pandemic.³ Factors contributing to this trend include increased health-related anxieties and reduced access to primary care services. Green *et al.* reported over a 25% reduction in general practitioner visits from 2019 to

mid-2021, potentially diverting patients to EDs as the only accessible care facility.²⁰ This trend underscores the need for strategies that bolster primary care access to prevent ED overcrowding with non-urgent cases during health crises.

We employed standardization of pediatric trauma data, which aligns with methodologies from prior studies,^{3,12,13} to control for fluctuations in ED attendance volumes and improve data reliability. The pandemic's irregular attendance patterns, driven by lockdowns and fears of viral transmission, necessitated such measures to ensure meaningful comparisons. By standardizing per 1000 ED attendances, we achieved consistency across time periods, enabling accurate cross-period comparisons and reducing potential bias due to confounding factors like shifts in healthcare-seeking behavior.

Standardization also facilitated the analysis of proportion-based outcomes (e.g., trauma rates) rather than raw numbers, which can be misleading when overall ED visits fluctuate. This approach allowed us to generate valid insights into trauma trends, independent of the broader pandemic-related variations in healthcare access.

This study's retrospective design could introduce biases; however, we used consistently collected, high-quality data. While certain variables, such as trauma location, were not included due to limitations in data granularity, the study's large sample size—over 10,000 pediatric trauma cases—enhanced the precision of findings despite the modest clinical significance of observed effect sizes. Excluding patients with severe life-threatening injuries or those with isolated head and thoracic traumas may limit generalizability. Additionally, we could not isolate data for local residents versus tourists, which may influence our conclusions.

The primary strength of our study is its use of ITSA and data standardization, providing robust insights into trauma trends over an extended period. This approach offers a reliable framework for understanding the long-term impacts of the COVID-19 pandemic on pediatric trauma, despite varied healthcare-seeking behaviors.

Conclusions

In conclusion, while COVID-19 notably reduced overall pediatric ED attendances for trauma, standardized data revealed a stable fracture rate across pre-, intra-, and post-pandemic periods, with initial declines in attendance during early 2020. The apparent stability in fractures per 1000 attendances suggests that pandemic restrictions limited certain trauma risks, such as those related to outdoor activities, without significantly affecting injuries within the home. An initial spike in dislocations was observed at the pandemic's onset, potentially reflecting increased trauma incidents in domestic environments, followed by a reversion to prior levels. These findings highlight the differential impact of COVID-19 on trauma types and underline the need for preparedness in healthcare systems to address shifts in trauma risks during public health emergencies. Our study contributes to a nuanced understanding of pediatric trauma trends during a global crisis, emphasizing the importance of data standardization in assessing healthcare disruptions.

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Online supplementary materials

Table 1. Distribution of ED orthopedic accesses by year and patient age

Table 2. Comparison of patient characteristics between before and after the outbreak of COVID-19 pandemic. Legend: ED: Emergency Department; MTS: Manchester Triage System; SD: Standard Deviation.

Table 3. Comparison of patient characteristics between before and after the outbreak of COVID-19 pandemic. Legend: ED: Emergency Department; MTS: Manchester Triage System; SD: Standard Deviation.

Figure 1. (A) Interrupted time series analysis assessing the rate of pediatric patients with fractures per 1,000 attendances to the ED orthopedic section per month. (B) Interrupted time series analysis assessing the rate of pediatric patients requiring a surgical intervention per 1,000 attendances to the ED orthopedic section per month.

Figure 2. Interrupted time series analysis assessing the rate of pediatric patients with dislocation per 1,000 attendances to the ED orthopedic section.