

Epidemiologic Changes in Pediatric Fractures Presenting to Emergency Departments During the COVID-19 Pandemic

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Background: Fractures are a common pediatric injury. The coronavirus disease 2019 (COVID-19) pandemic resulted in significant changes in daily life that could impact the incidence of pediatric fractures. The purpose of this study was to compare the incidence of pediatric fractures in the United States during the COVID-19 pandemic to previous seasonally adjusted fracture incidence rates using the National Electronic Injury Surveillance System (NEISS) database and the American Community Survey (ACS).

Methods: The NEISS database was queried from 2016 to 2020 for fractures occurring in pediatric (0 to 17 y) patients. ACS population data allowed for the estimation of fracture incidence per 1000 person-years. Using a quasiexperimental interrupted time series design, Poisson regression models were constructed to test the overall and differential impact of COVID-19 on monthly fracture rate by age, sex, fracture site, injury location, and disposition.

Results: Our sample consisted of 121,803 cases (mean age 9.6 ± 4.6 y, 36.1% female) representing $2,959,421 \pm 372,337$ fractures nationally. We identified a stable 27% decrease in fractures per month after February 2020 [risk difference (RD) per 1000 youth years = -2.3 ; 95% confidence interval: $-2.98, -1.57$]. We found significant effect modification by age, fracture site and injury location ($P < 0.05$). The fracture incidence among children 5 years or older significantly decreased, as well as the incidence of fractures at school [RD = -0.96 ($-1.09, -0.84$)] and during sports [risk difference = -1.55 ($-1.77, -1.32$)]. There was also a trend toward a reduction in upper extremity fractures and fractures requiring admission.

Conclusion: A nationally representative injury database demonstrated a 27% decline in monthly pediatric fractures during the COVID-19 pandemic that persisted into the latter half of 2020. These trends appeared most attributable to a reduction in fractures discharged home and upper extremity fractures among older children sustained at school and in sports. Our findings provide unique insight into the epidemiology of pediatric fractures and demonstrate a baseline need for musculoskeletal care among young children even in the setting of a national shutdown.

Level of Evidence: Level II—retrospective prognostic study.

Key Words: NEISS database, pediatric, fractures, COVID, COVID-19, pandemic, coronavirus, epidemiology, American Community Survey

(*J Pediatr Orthop* 2022;42:e815–e820)

Fractures regularly bring children to the emergency department with an annual incidence of 9.5 fractures per 1000 youth.^{1–3} Boys and adolescents face a higher risk, 1 potentially mediated by bone mass, bone mineral density, body mass index, and behavior.³ Over the past 2 decades, sports-related injuries have increased, with 74% of sports-related pediatric fractures occurring during football, basketball, baseball, and soccer.^{4,5} These predominantly upper extremity fractures not only carry significant pain and morbidity, but also represent a considerable financial and time burden to families.^{1–6}

Following the changes to daily life from the coronavirus disease 2019 (COVID-19) pandemic,⁷ several national and international studies examined its impact on pediatric fracture patterns. These authors identified a reduction in the average age of pediatric fracture patients, largely due to a significant reduction in the number of adolescent fractures.^{8–10} They also noted an increase in fractures occurring at home and on bicycles and a decrease in those related to sports, playgrounds, and motor vehicle collisions. Although past work has explored changes in pediatric fracture epidemiology during the COVID-19 pandemic, most are focused only on the first half of 2020 and none use a nationally representative sample.

The primary aim of this study was to evaluate changes in the national incidence of pediatric fractures during the COVID-19 pandemic. In doing so, we also hoped to identify potential targets for injury prevention programs and policies. We utilized the National Electronic Injury Surveillance System (NEISS) database to compare the pediatric fracture trend in 2020 to previous seasonally adjusted injury rates. We hypothesized that the incidence of pediatric fractures decreased in 2020 due to a decrease in the number of adolescent and sports-related injuries and that the impact of the pandemic on children before school age was negligible.

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This research study received no direct funding.

The authors declare no conflicts of interest.

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DOI: 10.1097/BPO.0000000000002194

METHODS

The NEISS was queried for all axial or appendicular pediatric (0 to 17 y) fractures that occurred between 2016 and 2020. The US Consumer Product Safety Commission (CPSC) contracts with a national probability sample of emergency departments in the United States to estimate the number of injuries related to consumer products.¹¹ We used the American Community Survey (ACS) to estimate the youth population of the United States over the study timeframe in order to estimate the incidence of pediatric fractures. We stratified the population estimates by age and sex when appropriate, and updated population estimates by year. Given the utilization of only publicly available, deidentified data, this study was exempt from review by our hospital’s Institutional Review Board.

We evaluated trends across the following characteristics: age, sex, fracture site, disposition, and injury location. For ease of analysis, patient age was categorized as infancy and early childhood (0 to 4 y), middle childhood (5 to 9 y), early adolescence (10 to 14 y), and late adolescence (15 to 17 y). Existing NEISS codes for fracture sites were categorized into head and neck, upper arm and shoulder, lower arm and elbow, wrist and hand, other

axial sites, thigh and hip, lower leg and knee, and foot and ankle. Injury location was coded as public space, residence, school, sports, and other/unknown. Of note, sports’ injuries were defined as those occurring in locations associated with recreation or organized sport, ranging from stadiums and swimming pools to amusement parks and mountains.¹² Disposition was categorized as discharged home or not discharged home.

Analyses were performed in R version 3.5.3.¹³ Using a quasiexperimental, interrupted time series design, Poisson regression models were constructed for incidence of fractures per 1000 children per month that included a linear time trend, month of injury, a binary variable representing whether the fracture occurred after February 2020, and number of months post-March 2020 to allow the effect of restrictions to change over time. The differential impact of COVID-19 on fracture rate by each demographic variable was then tested using interaction terms (Table 1). We then conducted exploratory post hoc tests to evaluate whether location accounted for the differential impact of COVID-19 by other variables. Effects are presented as annual incidence for ease of comparison.

TABLE 1. Incidence of Youth Fractures During the SARS-COV-2 Pandemic With 95% Confidence Intervals

	Prepandemic Incidence (1/2016-2/2020)	Peripandemic Incidence (3/2020-12/2020)	Rate Difference (March 2020)	Effect P	Rate Difference (September 2020)	Effect Decay P
Overall	8.03 (7.70, 8.37)	5.76 (5.16, 6.36)	-2.27 (-2.98, -1.57)	<0.001	-1.55 (-2.09, -1.02)	0.059
Age				<0.001		0.166
<5 y old	7.19 (6.76, 7.62)	6.45 (5.60, 7.29)	-0.74 (-1.72, 0.23)		-0.39 (-1.11, 0.33)	
5-9 y old	6.58 (6.18, 6.98)	4.20 (3.57, 4.84)	-2.38 (-3.14, -1.61)		-1.16 (-1.80, -0.52)	
10-14 y old	10.3 (9.85, 10.8)	7.11 (6.27, 7.96)	-3.21 (-4.19, -2.22)		-2.82 (-3.55, -2.09)	
15-17 y old	7.66 (7.13, 8.19)	4.72 (3.84, 5.60)	-2.94 (-3.99, -1.89)		-1.69 (-2.52, -0.86)	
Sex				0.154		0.572
Female	5.83 (5.51, 6.15)	4.50 (3.91, 5.09)	-1.33 (-2.02, -0.64)		-0.93 (-1.45, -0.41)	
Male	10.2 (9.77, 10.6)	6.94 (6.21, 7.67)	-3.25 (-4.10, -2.39)		-2.20 (-2.86, -1.54)	
Injury location				<0.001		0.004
Residence	2.10 (1.96, 2.23)	2.29 (1.98, 2.59)	0.19 (-0.15, 0.53)		0.06 (-0.17, 0.29)	
Public space	0.51 (0.44, 0.58)	0.40 (0.28, 0.52)	-0.11 (-0.26, 0.03)		-0.09 (-0.20, 0.02)	
School	1.16 (1.06, 1.25)	0.19 (0.11, 0.27)	-0.96 (-1.09, -0.84)		-0.85 (-0.98, -0.73)	
Sports	2.40 (2.26, 2.55)	0.86 (0.69, 1.03)	-1.55 (-1.77, -1.32)		-1.09 (-1.3, -0.88)	
Other/unknown	1.88 (1.75, 2.00)	1.86 (1.60, 2.12)	-0.02 (-0.32, 0.28)		0.43 (0.21, 0.65)	
Fracture site				0.001		0.579
Head and neck	0.52 (0.46, 0.57)	0.38 (0.29, 0.46)	-0.14 (-0.24, -0.04)		-0.09 (-0.17, 0.00)	
Upper arm and shoulder	1.21 (1.13, 1.29)	0.92 (0.78, 1.06)	-0.29 (-0.46, -0.12)		-0.25 (-0.37, -0.12)	
Lower arm and elbow	1.88 (1.79, 1.98)	1.46 (1.29, 1.64)	-0.42 (-0.63, -0.22)		-0.19 (-0.34, -0.03)	
Hand and wrist	2.53 (2.42, 2.64)	1.45 (1.28, 1.62)	-1.08 (-1.29, -0.87)		-0.72 (-0.89, -0.55)	
Other axial	0.13 (0.10, 0.15)	0.11 (0.06, 0.16)	-0.01 (-0.07, 0.04)		-0.02 (-0.06, 0.02)	
Thigh and hip	0.14 (0.12, 0.17)	0.13 (0.07, 0.18)	-0.02 (-0.08, 0.05)		-0.01 (-0.05, 0.04)	
Lower leg and knee	0.69 (0.64, 0.75)	0.63 (0.51, 0.75)	-0.06 (-0.20, 0.07)		-0.09 (-0.19, 0.00)	
Foot and ankle	0.94 (0.87, 1.00)	0.67 (0.55, 0.79)	-0.27 (-0.41, -0.12)		-0.21 (-0.31, -0.1)	
Disposition				0.072		0.534
Not discharged home	0.87 (0.78, 0.95)	0.75 (0.58, 0.92)	-0.12 (-0.31, 0.08)		-0.09 (-0.23, 0.06)	
Discharged home	7.17 (6.93, 7.41)	4.99 (4.57, 5.41)	-2.18 (-2.67, -1.68)		-1.47 (-1.85, -1.09)	

Incidence presented in 1000 youth years, P-values obtained from likelihood ratio tests of nested Poisson regression models. SARS-COV-2 indicates severe acute respiratory syndrome-related coronavirus.

RESULTS

Our NEISS query identified 121,803 cases (mean age 9.6 ± 4.6 y, 36.1% female) representing a national estimate of $2,959,421 \pm 372,337$ fractures occurring throughout the United States over the study period. This represents an overall annual incidence of 8.08 fractures per 1000 youth years over the study period, with an average annual incidence of 8.47 per 1000 youth years from 2016 to 2019 and an annual incidence of 6.55 in 2020. Overall trends are presented in Figure 1. Full incidence estimates and effects are presented in Table 1. A 27% decrease in the incidence of fractures occurred during the COVID-19 pandemic with a risk difference (RD) of -2.3 per 1000 youth years (95% confidence interval: $-2.98, -1.57$). The decay of this effect over the latter portion of 2020 did not reach significance ($P=0.06$). Given the trend in Figure 1 and the reported timing of increased youth physical activity,¹⁸ we conducted a post hoc analysis comparing the effect of the pandemic before June to the effect in and after June, reflecting summer and fall sports seasons. We noted significantly more fractures in the summer and fall ($P<0.001$), reflecting an 18% decrease from baseline [RD -1.55 ($-2.09, -1.02$)].

Results of injury characteristic effect modification testing are presented in Table 1. Significant differences were found in the effect of the pandemic by age, location of injury, and body region fractured. For children 5 years or older, the fracture incidence significantly decreased [RD 5 to 9 y = -2.52 ($-3.25, -1.78$), RD 10 to 14 y = -3.21 ($-4.19, -2.22$), RD 15 to 17 y = -2.94 ($-3.99, -1.89$) per 1000 youth years], but no incidence change was seen for children under the age of 5 years. We estimated a significant reduction in the rate of fractures at school [RD = -0.96 per 1000 youth years ($-1.09, -0.84$)] and during sports [-1.55 per 1000 youth years ($-1.77, -1.32$)], but found no significant differences in those occurring at other locations. After adjusting for injury location, no significant differential effect of the pandemic was noted based on age ($P=0.434$). Injury location continued to modify the effect of the pandemic on fracture incidence, even after age or fracture site adjustment ($P<0.001$). Pandemic risk differences by injury location and age are presented in Figure 2.

Notably, only the effect of location changed as the pandemic continued into the latter half of 2020. We probed this effect during September to evaluate trends once school resumed. In September, although there were still significantly fewer sports-related fractures as compared with prepandemic periods, the incidence rebounded from the early pandemic period [RD sports in September 2020 = -1.09 ($-1.30, -0.88$)]. There was also an increase in the rate of fractures in other or unknown locations [RD = 0.43 ($0.21, 0.65$)]. The reduced incidence of fractures in other known settings remained stable.

The pandemic led to fewer fractures discharged from the emergency department and upper extremity fractures. We found a significant decrease in patients with fractures that were discharged home from the emergency department [-2.18 ($-2.67, -1.68$)] but no difference in those

requiring admission [-0.12 ($-0.31, 0.08$)]. Although 27% of these fractures admitted occurred to the head or axial skeleton, 46% of them were to the upper extremity and 27% to the lower extremity. Nevertheless, the difference between the trends of admitted and discharged fractures was not significant ($P=0.072$), indicating that we have no evidence that the pandemic differentially affected the incidence of fractures based on disposition. The pattern of fractures also changed, with a significant decrease in fractures to the upper extremity [wrist and hand RD = -1.08 ($-1.29, -0.87$), elbow and lower arm RD = -0.42 ($-0.63, -0.22$), shoulder and upper arm RD = -0.29 ($-0.46, -0.12$)], head and neck [RD = -0.14 ($-0.24, -0.04$)], and foot and ankle RD = -0.27 ($-0.41, -0.12$)]. Pandemic risk differences by fracture site and injury location are presented in Figure 3. Fracture site differences remained significant after location adjustment ($P<0.001$), although the decrease in overall upper extremity fractures appears attributable to reductions in those occurring at school and sports.

DISCUSSION

Using a nationally representative sample of fractures presenting to US emergency departments, we identified a 27% decline in monthly pediatric fracture incidence during the COVID-19 pandemic. Our findings both validate and

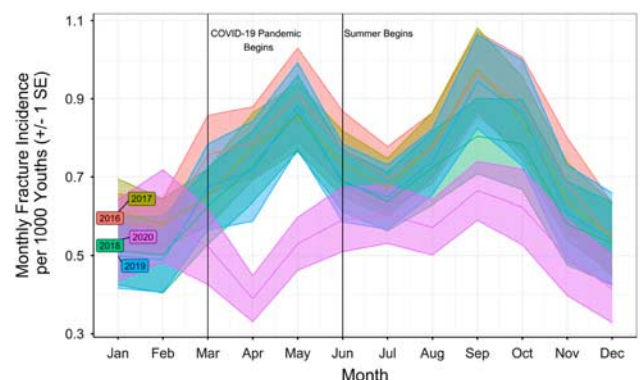


FIGURE 1. National Monthly Fractures Incidence from 2016 to 2020 (\pm SE). To provide further context for the injury statistics noted in the above figure, national school attendance and sport participation data is of relevance as a reduction in school enrollment was seen during 2020 in addition to a shift from in-person to distance learning. According to data from the National Center for Education Statistics (NCES), ~ 49.4 million students were enrolled in public prekindergarten through grade 12 in the fall of 2020, as compared with 50.8 million students in the fall of 2019.^{14,15} Data from the Household Pulse Survey (HPS) estimates that 72% of parents reported that their children’s classes had moved to distance learning in April 2020 while 67% of parents reported that their children’s classes had moved to distance learning in September 2020.¹⁶ Although formal data regarding sport participation during the pandemic is limited, a study by Dorsch and colleagues utilizing parent-reported surveys suggested a near 50% reduction in sports participation among respondents.¹⁷ COVID-19 indicates coronavirus 2019.

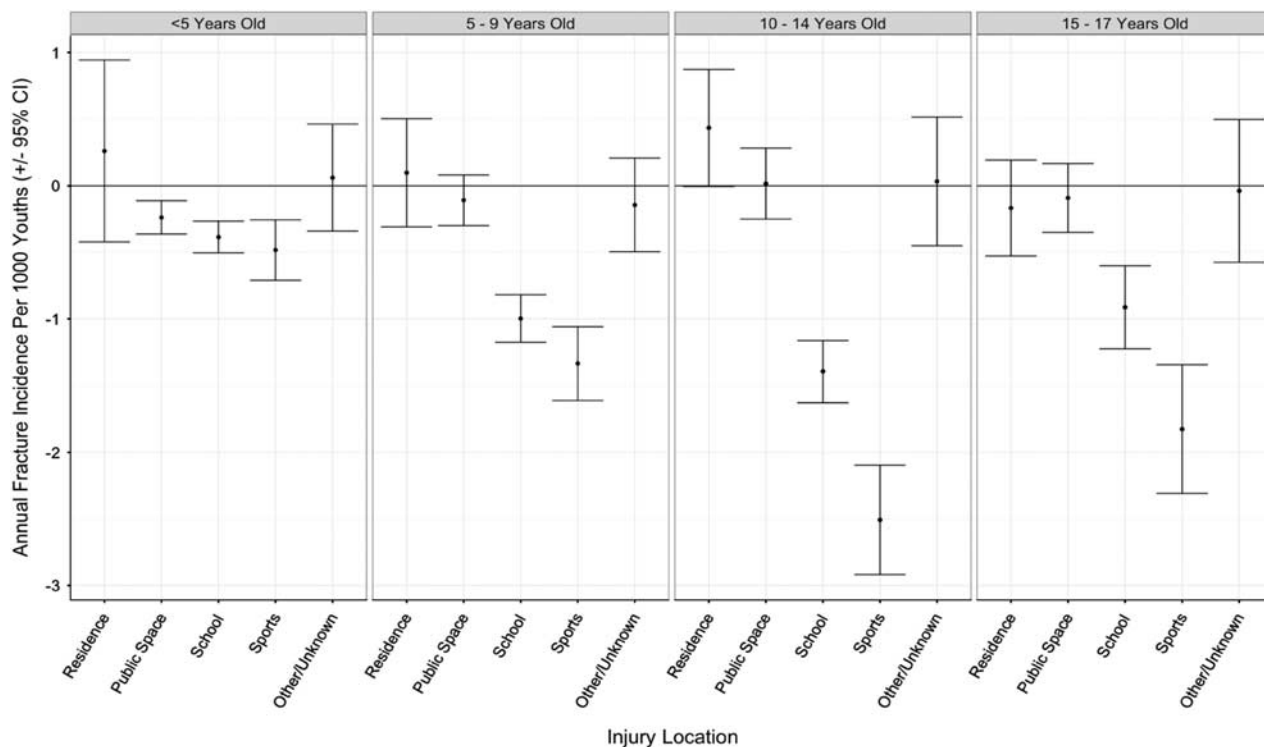


FIGURE 2. Risk difference in annual fracture incidence by injury location and age. CI indicates confidence interval.

expand upon smaller and regional investigations performed early in the pandemic.^{8,19–22} In addition, our findings indicate that these changes persisted even in the midst of fewer societal restrictions during the latter half of 2020. These trends appear attributable to a reduction in fractures discharged home and extremity fractures among older children sustained at school and in sports. Fractures admitted for management and those occurring in children before school age appear less impacted by the pandemic. Comparative analysis of fracture sites before and during the pandemic offers unique insight into the incidence of pediatric fractures. The pandemic-associated deviation from fracture norms highlights possible avenues for intervention.

Our study links the reduced incidence of fracture among school-aged children (5 to 17 y) to an overall decrease in school and sports-related injuries. Since the upper extremity is the most frequently fractured site during sports,^{23,24} the observed peripandemic decline in upper extremity fractures supports this connection. Several studies demonstrated that early in the pandemic, youth physical activity in the United States dropped, with parents reporting a roughly 50% reduction in time spent playing sports.²⁵ However, youth physical activity increased in the summer,¹⁸ and 44 states allowed for some level of school-organized sport in the fall.²⁶ Our overall trend in fracture incidence mirrors this trend in physical activity. Fractures occurring at school in this population remained low after March 2020, potentially reflecting the prevalence of distance learning during this period.²⁷ Although sport-related fractures did trend back toward prepandemic levels in the latter half of

2020, fractures occurring in other or unknown locations actually rose above their prepandemic baseline. We believe that this increase represents youth pursuing alternative forms of physical activity in the setting of organized sport being less readily accessible. This further validates findings from other authors identifying a rise in fractures sustained from trampoline and bicycle use.^{8,10,20} These shifts demonstrate the outcome of a natural experiment that restricted organized childhood physical activity.

Despite the significant reduction in overall fracture burden seen during the COVID-19 pandemic, the incidence of fractures requiring admission and those in young children (0 to 4 y) remained stable. As the literature on the effect of the pandemic on severe injury and non-accidental trauma is mixed,^{28–30} it is likely that this stability in fractures admitted for further management represents a composite of multiple pandemic-related changes. On one hand, many young children spent most of their time at home before the pandemic. On the other hand, these children likely engage in similar physical activities at home or daycare, so a change in location would have a negligible effect. As many remained in a residential setting throughout the pandemic, our study illustrates a stable risk of fracture in the home environment even in a national shutdown.

Our study findings suggest that school-aged children and adolescents may benefit most from sport-specific fracture prevention efforts, potentially focused on upper extremity fractures. Upper extremity fractures in sport have been linked to falls during play.³¹ Rule changes may

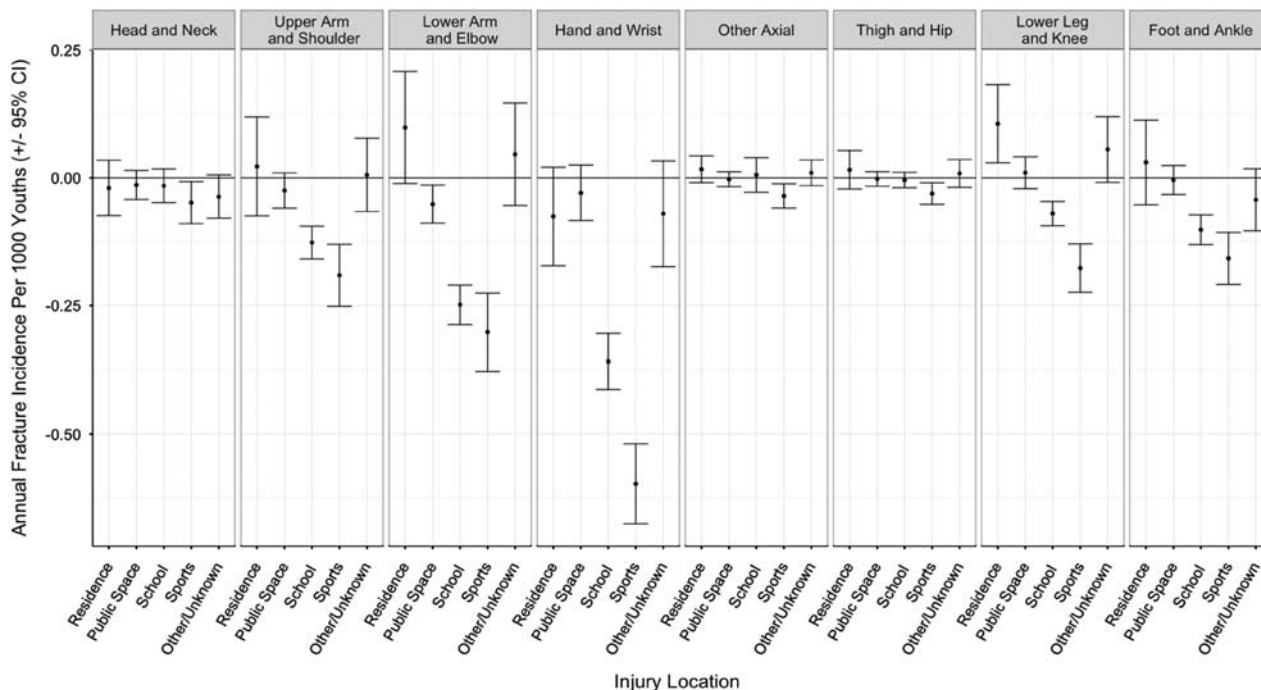


FIGURE 3. Risk difference in annual fracture incidence by injury location and fracture site. CI indicates confidence interval.

prove effective at limiting the number and severity of falls. For example, policy changes in ice hockey and American football have led to reduced head injuries.³² Increased adoption of upper extremity protective equipment may also help, as wrist guards have been shown to prevent wrist fractures in snowboarding.³³ Although organized sports contribute substantially to the occurrence of pediatric musculoskeletal injury, they have a myriad of empirically demonstrated benefits ranging from academic, to psychosocial, to physical health.³⁴ Young children would benefit from interventions centered on residential safety, as activity restrictions did not appear to affect their overall risk.³⁵ Finally, our findings offer insights which may streamline health system responses to future pandemics. Although overall fracture incidence declined during the COVID-19 pandemic, injuries requiring hospitalization remained largely unimpacted while many other departments were overwhelmed by increased patient volume and costs.³⁶⁻³⁸ Despite a significant reduction in organized childhood physical activity in the midst of a pandemic, there remained a significant baseline need for inpatient and outpatient orthopaedic care.

The inferences from our study are necessarily limited. First, the demographics, injury diagnoses, and management included in the NEISS database are limited in detail which prevents a more detailed analysis of specific injury patterns and treatment considerations. NEISS also only samples emergency departments, so we could not account for fractures presenting to urgent care centers or outpatient pediatric or orthopaedic facilities. Since many pediatric fractures can be diagnosed and treated in an outpatient setting, we likely underestimate the overall

incidence of minor fractures.¹⁹ Presented findings represent national estimates, however, the impact of the pandemic on school and sport was notably variable throughout 2020 given the regional heterogeneity of COVID-19 policies. Nevertheless, we believe our findings provide the most generalizable data of any existing work given the utilization of a validated, nationally representative sample. Finally, fear of exposure or overcrowding during the COVID-19 pandemic may have led families to seek more care outside of emergency rooms. This could lead to an overestimate of the decrease in fractures during the pandemic. However, given the pain and debility associated with any fracture, we believe such an effect to be small.

Pediatric fractures represent a significant physical, emotional, and financial burden to families nationwide. Although the incidence of these fractures has steadily increased over the past few decades, the COVID-19 pandemic provided a natural experiment to understand the relationship between school and sport engagement and fracture incidence. Using the NEISS database, this study identified a significant reduction in overall incidence of pediatric fractures treated in emergency departments that was most pronounced among school-aged children and adolescents. Pandemic changes appeared to have the greatest impact on the occurrence of upper extremity fractures and those sustained at school and sports. Beyond demonstrating the effect of a pandemic, this study quantifies the burden of childhood fractures because of school and sport participation and demonstrates a baseline need for musculoskeletal care among young children. Further research should include identifying specific,

modifiable risk factors to develop and implement strategies and age-specific safety interventions aimed to decrease the overall pediatric fracture burden.

ACKNOWLEDGMENTS

The authors thank Dr Diana C. Montoya-Williams for her review of this manuscript and valuable input into the statistical methodology and presentation of results.

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