

Impact of the COVID-19 Pandemic on Pediatric Elbow Fractures: Marked Change in Management and Resource Utilization, Without a Change in Incidence

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Background: Elbow fractures are the most common pediatric fractures requiring operative treatment. Although recent reports have suggested that the COVID-19 pandemic has markedly reduced the incidence of pediatric fractures, no study has specifically evaluated the impact on pediatric elbow fractures. This study aimed to evaluate changes in the incidence, severity, and resource utilization for managing pediatric elbow fractures during the COVID-19 pandemic, compared with prepandemic years. **Methods:** A prepandemic (2007 to 2017) cohort and a COVID-19 pandemic period (March 2020 to March 2021) cohort of pediatric elbow injuries from a single tertiary hospital were retrospectively examined and compared. Exclusion criteria included outside treatment or lack of diagnosis by an orthopedist. Presentation information, injury patterns, transport, and treatment requirements were collected.

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Results: Although the incidence of pediatric elbow fractures and rate of neurovascular injury were comparable, seasonal patterns were not sustained and the rate of fracture displacement was found to be significantly elevated in the COVID-19 period compared with nonpandemic years. Likewise, marked changes to where patients first presented (emergency department vs. Clinic), how the patients were transported, and the distance traveled for care were observed. Specifically, patients were more likely to present to the clinic, were more likely to self-transport instead of using emergency medical service transportation, and traveled a greater distance for care, on average. Aligning with these changes, the resources utilized for the treatment of pediatric elbow fracture markedly changed during the COVID-19 period. This study found that there was an increase in the overall number of surgeries performed, the total operative time required to treat elbow fractures, and the number of patients requiring admission during the COVID-19 period.

Conclusions: These data provide a contrasting viewpoint to prior reports, illustrating that the incidence of elbow fractures remained consistent during the COVID-19 period, whereas the operative volume and need for hospital admission increased compared with years prior. Furthermore, this study demonstrated how the COVID-19 pandemic altered the interface between pediatric patients with elbow fractures and our institution regarding the location of presentation and transportation.

Level of Evidence: Level III—retrospective cohort study.

Key Words: pediatric elbow fractures, elbow fractures, resource utilization, COVID-19

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Elbow fractures are the most common pediatric fractures that require operative fixation,^{1–3} making them a significant source of resource utilization.^{4–6} Through the development and use of the largest single-center retrospective cohort study of pediatric elbow fractures spanning 2007 to 2017, our group previously examined the annual seasonal pattern of pediatric elbow fracture incidence and severity, and the impact of these patterns on resource utilization in the emergency department (ED), emergency medical service transport, and the operating room (OR).⁷ This study concluded that increased hours of daylight and school being in

session were major drivers of the incidence of pediatric elbow fractures. Although summer vacation from school conferred fewer fractures than surrounding months with increased daylight hours, the fractures were found to be more severe, as evidenced by higher rates of displacement and a higher risk for neurovascular injury. As such, increased daylight correlated strongly with monthly resource utilization, including the need for emergency transportation and operative treatment.

The COVID-19 pandemic has created numerous challenges for both health care providers and facilities, as well as patients and families across the world. Specifically, there have been reports of decreased patient access to health care during the pandemic.^{8,9} Both public health measures and changes in individual behavior have affected many of the factors previously shown to correlate with a higher pediatric trauma volume. COVID-19–related changes such as social distancing, remote learning, and reduced access to playgrounds are possibly being linked to a decreased incidence of traumatic fractures in children over the past year.^{10–12} The objective of this study was to specifically evaluate changes in the incidence, severity, and resource utilization for managing pediatric elbow fractures at our institution during the COVID-19 pandemic, compared with prepandemic years (2007 to 2017).

METHODS

With Institutional Review Board approval (IRB# 171899), Current Procedural Terminology codes (CPT: 24530, 24535, 24538, 24545, 24546, 24560, 24565, 24566, 24575, 24576, 24577, 24579, 24582, 24586, 24600, 24605, 24615, 24620, 24635, 24650, 24655, 24665, 24666, 24685) were used to identify pediatric (age 0 to 17) patients diagnosed with and treated for elbow injuries from March 2020 to March 2021 (designated as the COVID-19 study period) at a large tertiary medical center and its affiliated clinics. All treating physicians were either fellowship-trained pediatric orthopaedic surgeons or fellowship-trained pediatric non-operative sports medicine providers. The electronic medical records were used to retrospectively collect data on patient presentation, injury, transport, and management. These data were then compared with a previously constructed institutional database containing identical variables spanning all pediatric patients treated for elbow injuries between 2007 and 2017. All deidentified study data were collected and managed using REDCap.^{13,14}

To estimate fracture severity, fracture displacement and the presence of concomitant neurovascular injury were collected. Nerve injury was defined for this paper as any motor deficit or persistent sensory deficit documented in a defined anatomic distribution on physical examination. Persistent sensory deficit was defined as a sensory deficit present at time of injury that persisted through initial follow-up. Any documented vascular deficit, including preoperative lack of pulses or doppler signal was included in this study. Elbow injuries were separated into either displaced or nondisplaced injuries as previously conducted.⁷ Patient presentation was defined as the place

of initial patient presentation for elbow fracture and was categorized as either scheduled or walk-in clinic visits versus ED. Patient transport was categorized as either self-transportation (in a personally operated vehicle) or emergency medical services transportation (by either ambulance or air transport). Distance of travel was calculated from the center of each patient's county of residence to the research institution. Variables regarding elbow injury treatment included mode of treatment (operative vs. nonoperative), admission to the hospital, and total OR time spent treating elbow injuries. Total OR time for the COVID-19 study period was obtained from departmental databases.

Both the institutional 2007 to 2017 database and the COVID-19 study period data failed normality testing, therefore nonparametric testing was used throughout. Comparisons of categorical data were made using Fisher Exact test, and comparisons of categorical data were made using the Mann-Whitney U test. A *P*-value <0.05 was significant. All statistical calculations and figures were generated with GraphPad Prism version 8.0.0.

RESULTS

Pediatric Elbow Fracture Incidence

This study identified 477 patients presenting with elbow fractures during the COVID-19 study period compared with a total of 4414 patients in the 2007 to 2017 database. Contrary to prior reports, the elbow fracture incidence during COVID-19 was well within the range of the non-COVID years (range: 393 to 506). Unlike prepandemic years, the incidence of elbow fractures did not associate with increased daylight ($r = 0.42$ during COVID-19 vs. 0.79 in 2007 to 2017, Fig. 1A) or local academic calendars. Rather, the peak incidence of fractures during the COVID-19 study period was observed in November (58 elbow fractures), which historically at our institution was a month of lower incidence (Median: 29 elbow fractures/November 2007 to 2017). Furthermore, although in prior years (2007 to 2017), our institution observed an 11.4% decrease in fracture incidence observed during summer vacation months compared with the surrounding warmer months in which school was in session, this trend was not observed during the COVID-19 study period, aligning with statewide school closures in the Spring of 2020.

Although no marked variance in elbow fracture pattern was observed between the 2 study periods (Pre COVID-19: 64.5% supracondylar, 12.5% lateral condyle, 10.1% radial neck, 4.4% Monteggia, 3.6% medial epicondyle, 3% dislocation, 1.3% olecranon. During COVID-19: 63.3% supracondylar, 13.2% lateral condyle, 7.8% radial neck, 5.5% Monteggia, 4.2% medial epicondyle, 2.9% dislocation, 1.3% olecranon, Supplemental Table 1, Supplemental Digital Content 1, <http://links.lww.com/BPO/A514>), the rate of fracture displacement was significantly elevated during the COVID-19 study period at 64.6% (307/477) compared with 51.9% (2291/2123) in the previous years ($P < 0.001$, Fig. 1B). Between the 2 study periods, there was a similar rate of

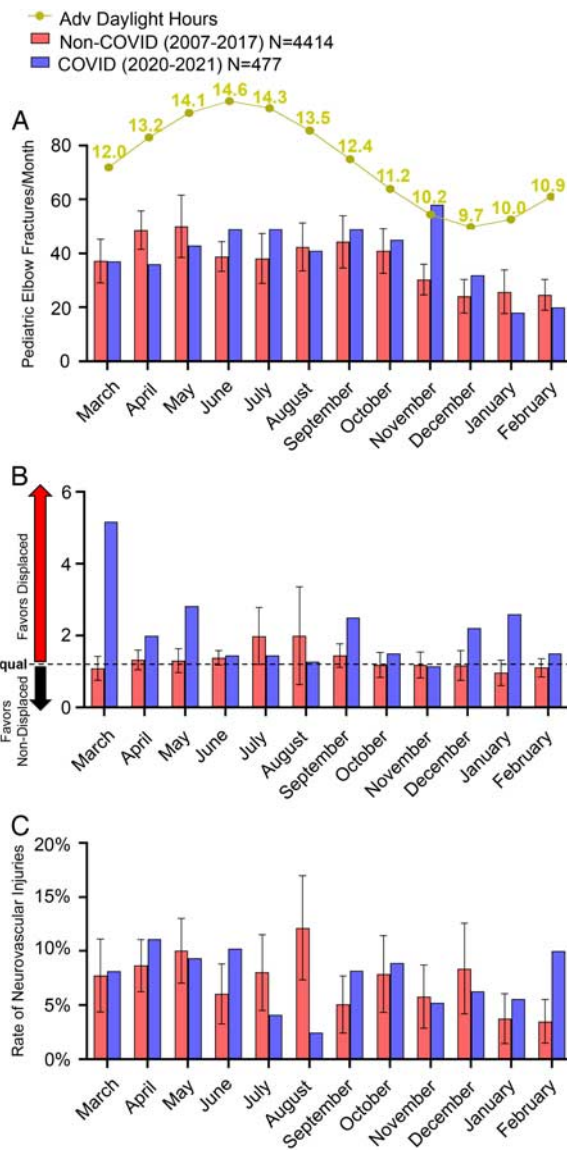


FIGURE 1. Fracture incidence and severity during the COVID-19 pandemic. A, Monthly average incidence in elbow fractures between the COVID-19 study period, and prior years, relative to average hours of daylight. The curve of average monthly daylight per month is overlaid over both graphs to display the high correlation of daylight to fracture incidence in the 2007 to 2017 study period ($r=0.79$) compared with the much weaker correlation during the COVID-19 study period ($r=0.42$). B, Ratio of displaced versus nondisplaced fractures per month where 1 indicated equal incidence. C, Rate of neurovascular injury per month. All error bars represent the 95% confidence interval.

concomitant neurovascular injury during the COVID-19 study period (7.3%, 35/477) as in prior years (mean: 6.8%, range: 4.7% to 8.7%, $P=0.657$, Fig. 1C). Whereas a strong correlation between daylight savings time and the rate of displaced fracture or concomitant neurovascular injury was observed between 2007 to 2017,⁷ these trends were not observed during the COVID-19 study period.

Pediatric Elbow Fracture Care

During the COVID-19 pandemic, pediatric patients were 32.5% more likely to initially present with their elbow injury to a clinic versus the ED than in prior years (29.1%, 139/477 during COVID-19 vs. 22.0%, Fig. 2A, $P<0.001$). This trend was found to be consistent throughout the COVID-19 months, apart from January 2021 when there was an increase in patients initially presenting to the ED compared with years prior and the surrounding months. Moreover, patients were more likely to be transferred to the study institution in the COVID-19 time period (333/477, 69.8%) compared with the non-COVID time period (2582/4414, 58.5%). In addition to changes in presentation location, we observed that families traveled a greater distance for management of elbow injuries during the COVID-19 pandemic study period. On average patients traveled 43.3 miles/patient versus 32.4 miles/patient in 2007 to 2017 (Fig. 2B–D) and were significantly more likely to self-transport in privately owned vehicles rather than by emergency medical service transportation (68.4%– COVID-19 vs. 59.1% in 2007 to 2017, Fig. 2E, $P<0.001$), compared with years prior.

When considering resources required to treat, this study found that there was an increase in the overall number of surgeries performed to treat elbow fractures during COVID-19 compared with 2007 to 2017 (COVID-19: 291, 2007 to 2017: range: 212 to 255, Fig. 3A). Of the 291 operative patients, 234 (80.4%) had documented COVID-19 screening within 72 before surgery. The 57 without documented screening had surgery before the institution of hospital standardized screening protocol in early May 2020. Of the 234 patients with screening, only 2 patients (0.8%) had positive tests. These patients had no major delays in surgery and anesthesia was performed per hospital COVID-19 protocol. Nonoperative patients were not routinely screened. Although elbow fractures accounted for 12.3% of all pediatric orthopaedic operations in 2007 to 2017,⁷ during the COVID-19 period, operations to treat elbow fractures made up 16.5% of all pediatric orthopaedic operations. This proportion varied throughout the year, peaking in April 2020 with 25.3% of all pediatric orthopaedic operations being for the treatment of elbow fractures, aligning with a decrease in total procedures that month. Likewise, aligning with an increase in the number of operations to treat elbow fractures, during the COVID-19 years an increase in total operative time required to treat elbow fractures per year was observed (COVID-19: 451.2 operative hours, 2007 to 2017: range: 285.8 to 353.8 operative hours). Finally, during the COVID-19 years, an increase in the number of patients requiring admission per year was observed (COVID-19: 221 admissions, 2007 to 2017: median: 201 admissions (range: 171 to 229 admissions). Importantly, however, the proportion of operative fractures that were admitted to the hospital (vs. returning for outpatient surgery) was 0.76 during the COVID-19 time period compared with 0.86 in the 2007 to 2017 time period. These changes in operative injuries led to multiple months during the COVID-19 study period

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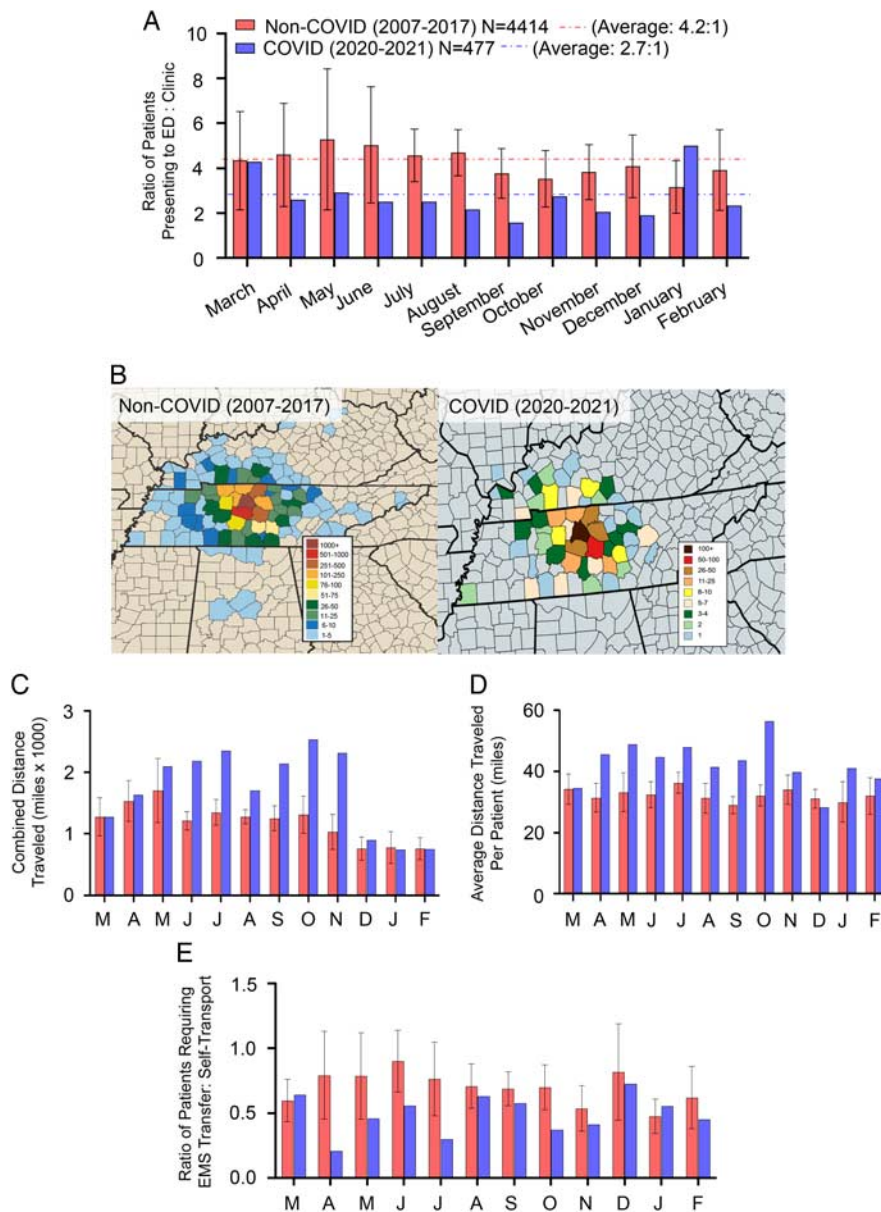


FIGURE 2. Fracture presentation and transportation during the COVID-19 pandemic. A, Ratio of patients presenting to the emergency department (ED) compared with a pediatric orthopaedic clinic. Although presentation rates to the ED were 4.2:1 between 2007 and 2017, patients were found to be present at clinics more frequently during the COVID-19 pandemic, resulting in an average rate of presentation to the ED of 2.7:1. B, Map of the study region with counties shaded by volume of patients presenting from each county during the 2 study periods. C, Total distance traveled by families per month for fracture care, (D) the average distance traveled per patient per month during both study periods. E, The ratio of transport by emergency medical service transportation (vs. self-transportation) per month is shown for each study period. All error bars represent the 95% confidence interval.

reporting $\geq 100\%$ increase in the number of operations, the operative time required, or the number of patients being admitted for care compared with monthly averages between 2007 and 2017 (Fig. 3).

DISCUSSION

Reports have suggested that traumatic fracture incidence in children has decreased during the COVID-19

pandemic.¹⁰⁻¹² Evaluation of elbow fracture care at our institution provides a contrasting viewpoint. At our institution, the incidence of elbow fractures did not change, but rather, operative volume and need for hospital admission increased during the COVID-19 pandemic compared with a prior 10-year sample of data. Likewise, this study illustrated marked variation in the mode of transportation and location of presentation for children with

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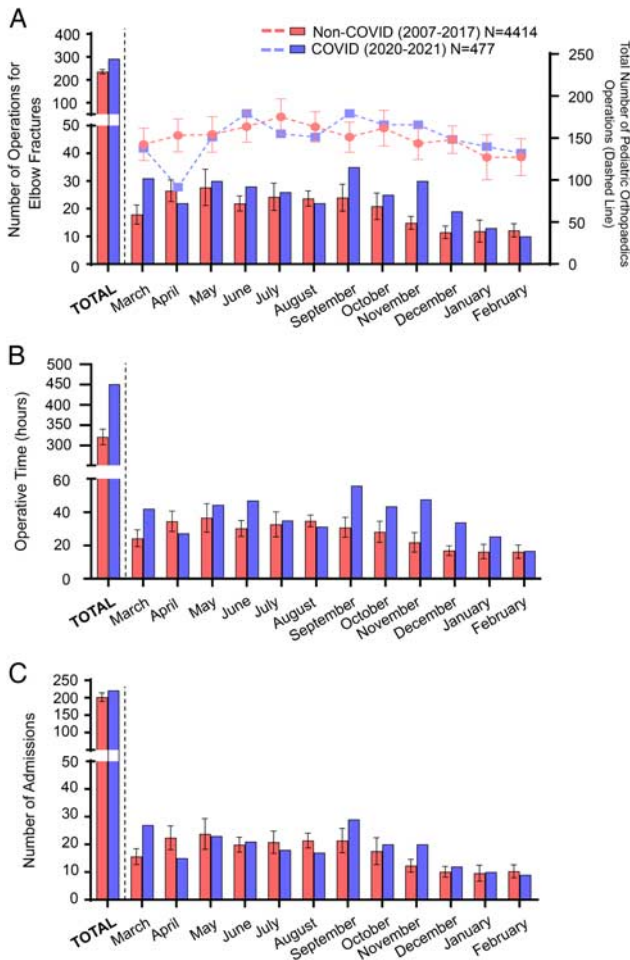


FIGURE 3. Operations management of pediatric elbow fracture during the COVID-19 pandemic. A, The average number of operations per month to treat pediatric elbow injuries during the 2 study periods (bar graph) in relation to the total number of pediatric orthopaedic operative procedures performed per month. B, Average operative time utilized for the treatment of pediatric elbow fractures per study period. C, Number of hospital admissions required for the treatment of pediatric elbow fracture per study period. Error bars represent the 95% confidence interval.

elbow fractures during the COVID-19 pandemic. Interestingly, despite an increase in displaced (ie, more severe) fractures during the COVID-19 study period, patients more frequently presented to the clinic versus the ED and more frequently utilized self-transport over emergency medical transport, compared with years prior (2007 to 2017). Together, these results help further illustrate how the COVID-19 pandemic has impacted injury epidemiology and the interface between patients and health care.

To gain additional insight into the variation in incidence and operative needs between months during the COVID-19 pandemic study period, a timeline of the local social and legislative response to COVID-19 was constructed (Supplemental Figure 1, Supplemental Digital Content 2,

<http://links.lww.com/BPO/A515>). The COVID-19 timeline included not only the initial months of the pandemic but also the subsequent year. The goal of including a full year was to capture not only the temporal changes during the peak effect of pandemic-related restrictions but also the responses upon relaxation of those restrictions. The disruption of local school schedules with school closures starting in late March combined with other societal responses could potentially explain the decreased correlation between daylight hours and fracture incidence seen in the COVID-19 study period. Expectedly, the initial shutdown of nonessential businesses and statewide school closures in March to May 2020 resulted in lower fracture incidence compared with previous years. Interestingly, however, the incidence of elbow fractures stayed consistent throughout the summer months, followed by an unexpected peak incidence of elbow fracture in November, which occurred in conjunction with a brief reopening with the major local school system (Davidson County) from late October to November.

Although the incidence of fractures seen during the COVID-19 study period was relatively consistent, and well within the previously observed range, there was marked variation in the operative needs and resource utilization. For example, During the COVID-19 period, there was an increase of 55.7 operations/year (range: +36 to +79 more operations than years prior (2007 to 2017)) for the treatment of elbow fracture, resulting in an additional 130.6 yearly operative hours (range: +97.4 to +165.4 more operative hours than years prior (2007 to 2017)). Although this increase in operative time may be in part due to the increased number of operations and increased severity of elbow fractures, it is likely also influenced by changes in OR personnel during the COVID-19 pandemic. When elective surgical procedures were postponed in mid-March 2020 (Supplemental Figure 1, Supplemental Digital Content 2, <http://links.lww.com/BPO/A515>) resulting in a decrease in the total number of pediatric orthopaedic operations performed (Fig. 3), the need to operatively care for traumatic elbow injuries was maintained. As such, in April 2020, 25.3% of all pediatric orthopaedic operations performed were for the treatment of elbow fractures. Finally, this study observed an increase in the raw number of admissions for the treatment of elbow fractures during the COVID-19 study period, but an overall decreased proportion of operative fractures that were admitted. This change is likely multifactorial due to changes in incidence, elevated severity of elbow fracture, increased distances traveled by families, variable location of presentation, and the operative resources and personnel available. Together these findings illustrate broadly how the COVID-19 pandemic has impacted the operative management of pediatric elbow fracture and the associated hospital resources required to treat.

During the COVID-19 study period, the interface between pediatric patients with elbow fractures and our institution varied significantly. Previous studies have reported decreased access to care and routine screening during COVID-19,^{8,9,15} and although this study was not designed to assess access to care during the pandemic, we were able to identify major changes in how patients

received care, especially regarding presentation and transportation to medical facilities. Specifically, despite potentially more severe injuries as demonstrated by the overall higher rate of displaced fractures, patients were more likely to present to clinics than in previous years. We hypothesized these changes may be due to altered transferring protocols from community hospitals or patient preference to limit potential exposure to individuals with COVID-19 infections who may be present in large EDs. This increased rate of presentation in the outpatient setting also likely contributes to the overall decreased proportion of hospital admissions for operative elbow injuries. Although long-term outcomes data for this cohort are currently unavailable, the increased rate of presentation to outpatient clinics could provide a valuable analysis of outpatient elbow injury fixation, especially in light of recent trends toward outpatient fracture fixation with increasingly more severe fractures.¹⁶

This study likewise observed that the proportion of patients treated for elbow injury that were transferred from another clinic or hospital increased during the COVID-19 period. Although we hypothesized this may be to limitations and increased volume at local hospitals secondary to the pandemic, given the multiple points of entry for patients to our tertiary care center and the variety of medical professional involved in this process, the specific causes for a change in transfer protocols remain difficult to assess. Future focused investigations would be required to determine the factors driving the changes in transfer protocols within our local medical care system.

Finally, the proportion of patients self-transporting and the total distance traveled for care of an elbow fracture both increased during the COVID-19 pandemic compared with prior nonpandemic years (2007 to 2017). This could potentially be due to (1) increased flexibility with parent work schedules allowing them to transport their injured children, (2) altered location of where injuries are occurring (home vs. at school), and/or (3) altered capacity for outside hospitals or emergency transport services to provide care, resulting in increased distances traveled by families. Importantly, these trends in access to care seen during the COVID-19 time period may support increased flexibility in how treatment is provided for elbow fractures. Specifically, the increased rates of presentation to clinics as opposed to EDs, the decreased rate of emergency transport utilization compared with self-transportation, and the decreased proportion of patients admitted to the hospital for operative fractures are all trends seen that could potentially be extended to nonpandemic settings to decrease the volume burden on emergency medical transport and EDs at tertiary hospitals. In addition, there is a potential for reducing health care costs with utilization of these trends as well. Future, targeted, studies aimed at assessing such practice changes are warranted.

Strengths and Limitations

This study was made possible by previously amassing the largest comprehensive cohort of pediatric elbow fractures from a single center, allowing for comparison of

elbow fracture occurrence, severity, and resource utilization during the COVID-19 pandemic. However, given the retrospective nature of the study, there were limitations in our ability to assess location and mechanisms of injury, limiting our ability to make statements about causation and prevention of injuries. Furthermore, as a tertiary referral center with a pediatric ED, our population is likely biased toward severe cases requiring treatment from specialists, operative intervention, and/or hospital admission. Although it is anticipated that less severe fractures tend to remain at regional hospitals and medical centers for care, given that we have not collected data from surrounding regional hospitals, we cannot explicitly state the effects of the COVID-19 pandemic on their care or transfer of pediatric elbow fractures. Likewise, as a single-center study, these results are only representative of our center and the surrounding region. We acknowledge these limitations and believe that the data remain a useful inference into the effect of the COVID-19 pandemic on the occurrence, severity, and resource utilization for the treatment of pediatric elbow fractures.

CONCLUSION

Together, these data demonstrate that at a large pediatric tertiary care center, although the incidence of pediatric elbow fractures did not vary markedly during the COVID-19 study period, the pandemic elicited significant changes in how patients accessed health care compared with years prior. Importantly, this study also found that the resources required for treatment, including an increased need for operative care, increased OR time, and increased need for hospital admission, markedly changed during the COVID-19 study period. Together, these findings provide objective data by which providers and administrators can more accurately allocate resources in the future.

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