


## ORIGINAL RESEARCH

## Pediatrics

# Pediatric appendicitis in the time of the COVID-19 pandemic: A retrospective chart review

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**Abstract**

**Aim:** Conduct a time trend analysis that describes 2 groups of patients admitted to a large tertiary children's hospital that presented with appendicitis and determine if there was an increase in complicated appendicitis when compared between 2 time periods before and during the early coronavirus disease 2019 (COVID-19) pandemic of 2020.

**Methods:** We conducted a retrospective analysis of all children presenting to a single-center site with appendicitis between March 23 and August 31, 2020, in the Central Texas region. We compared 507 patients presenting with appendicitis from the non-COVID-19 era in 2019 with  $n = 249$  to patients presenting during the COVID time period with  $n = 258$ . All patients with appendicitis within those time periods were reviewed with analysis of various characteristics in regard to presentation, diagnosis of uncomplicated versus complicated appendicitis, and management outcomes.

**Results:** There were no significant demographic differences or change in the number of appendicitis cases noted between the 2 time periods of comparison. There was no significant difference in rates of complicated appendicitis or presentation time following symptom onset between the 2 eras. There was no significant difference in intra-operative or postoperative complications. There was a statistically significant increase in the use of computed tomography (CT) scans ( $P$ -value = 0.004) with patients 1.81 times more likely to have a CT scan in the pandemic era after adjusting for patient-level factors. The effect of severe acute respiratory syndrome coronavirus 2 status on outcomes was not part of the data analysis.

**Conclusion:** Our study is the largest to date examining appendicitis complications in the era of COVID. In the time of the COVID-19 pandemic, we found no delay in presentation in children presenting to the emergency department and no increase in complicated appendicitis. We did identify an increase in the use of CT scans for definitive

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diagnosis of appendicitis noted in the pandemic era. Although COVID-19 status was not studied, the finding of increased CT use for a definitive diagnosis of appendicitis was a distinctive finding of this study showing a change in practice in pediatric emergency medicine.

**KEYWORDS**

appendicitis, complicated appendicitis, COVID-19, CT scan, pandemic, pediatrics, pediatric emergency medicine

## 1 | INTRODUCTION

### 1.1 | Background

Appendicitis is the most common gastrointestinal condition requiring surgical management in the pediatric age group with 70,000 cases diagnosed annually in children.<sup>1</sup> Appendicitis may present along a spectrum of severity, from isolated inflammation of the appendiceal wall to perforation, the latter of which may lead to bacterial seeding of the abdominal cavity with associated peritonitis and abscess formation.<sup>2,3</sup> Appendicitis is the most costly surgical disease treated in the pediatric population.<sup>4</sup> For the purposes of clinical research and the practical considerations of reimbursement policy, this spectrum of severity has been represented by categorizing appendicitis as complicated or uncomplicated.<sup>5</sup> There has been debate regarding an appropriate and meaningful definition for these terms. The National Surgical Quality Improvement Program (NSQIP) has proposed a set of 4 independent criteria to define complicated appendicitis, including: a visible perforation in the appendix, abscess formation, diffuse fibrinopurulent exudate, and extra-luminal fecalith in the peritoneal cavity that are defined intraoperatively.<sup>4,6</sup> The relevance of these criteria has been supported by a multi-institutional analysis demonstrating each of these individual criteria to be independently associated with adverse events (surgical site infections, pneumonia, sepsis, urinary tract infection), hospital revisits, and overall higher hospital costs. Given the implications of a complicated presentation, avoiding delays in diagnosis or misdiagnosis is critical to reducing morbidity and mortality.<sup>7</sup> Timely diagnosis is particularly relevant for the pediatric population, which suffers from higher rates of perforation compared to adults. Several studies have attempted to identify predictive factors associated with more severe presentations of appendicitis.<sup>8-10</sup> Pre-hospital factors which demonstrated correlation with perforated appendicitis included: younger age (<9 years), longer symptom duration ( $\geq 2$  days), fever (axillary temperature  $\geq 38.0^{\circ}\text{C}$ ), vomiting, and diarrhea.<sup>11,12</sup>

### 1.2 | Importance

The pandemic caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been found to lead to an overall delay in patients seeking care given the fear of contracting the virus and

the uncertainty of circumstances early on as demonstrated in numerous studies.<sup>13-15</sup> In the pediatric population, parental concern and fear of contracting coronavirus disease 2019 (COVID-19) was found to be a contributing factor leading to a notable delay in seeking treatment for many other non-emergent illnesses.<sup>13</sup> Our investigation is timely because the unrelenting nature of the pandemic has continued on in the pediatric population. The effect of the virus continues beyond expectations in terms of time and impacts on health outcomes, even more so as the virus mutates and takes more of a toll on younger populations of patients.

### 1.3 | Goals of this investigation

Our study aimed to assess if there may have been a higher incidence of complicated appendicitis compared to uncomplicated appendicitis during the COVID-19 pandemic.

## 2 | METHODS

### 2.1 | Study design and setting

We conducted a time trend analysis of children less than 18 years old who presented to a large tertiary children's hospital and were ultimately diagnosed with appendicitis during 2 discrete 23-week time periods of the non-COVID-19 era (March 23 to August 31, 2019) compared to the early COVID-19 era (March 23 to August 31, 2020).

### 2.2 | Selection of participants

Dates of comparison were from March 23 to August 31, 2019 as the control group compared to the same period in 2020. Inclusion criteria was children ages 0 to <18 years, admitted to an urban pediatric hospital for appendicitis, discharged with a diagnosis of appendicitis (including complicated appendicitis, ie, with abscess, visible perforation, extraluminal fecalith, and diffuse fibrinopurulent exudate) who either required operative or nonoperative intervention, including drain placement with interventional radiology (IR). We excluded patients without a final diagnosis of appendicitis. The final diagnosis of

### The Bottom Line

In the face of the COVID-19 pandemic, it is important to not forget about other etiologies of disease, such as appendicitis. This retrospective review demonstrated a delay in diagnosis as well as increase in use of computed tomography scans for diagnosis of appendicitis in children during the COVID-19 era.

appendicitis and the presence of complicated appendicitis were determined by International Classification of Diseases (ICD) 9/10 diagnosis codes in conjunction with a detailed review of the operative report. In total, 507 patients met criteria for a diagnosis of appendicitis with 249 in the non-COVID-19 era and 258 in the COVID-19 era. Total appendectomies were performed on 247 patients in the non-COVID-19 era and 255 patients in the COVID-19 era.

## 2.3 | Exposures

The variables collected were age, sex, race/ethnicity, insurance status, time to presentation from symptom onset, length of stay (LOS), need for ICU admission, appendicitis severity measures, need for surgery, post-surgical complications, imaging, and COVID-19 status. COVID-19 status was obtained once testing became available, but early on in the pandemic, some patients were not tested due to lack of testing capability. Data was queried based on ICD 9/10 codes for appendicitis and using CPT codes (44960 Appendectomy and 44970 Laparoscopic appendectomy).

## 2.4 | Measurements

All study data were sourced from existing hospital administrative databases or abstracted from the electronic medical record by trained research personnel. Data elements contained in operational databases were sourced through database query and added to a Redcap database. Additional variables of interest were abstracted from the medical record of each patient and entered manually into the database. All data abstractors were trained and oversight of all data was maintained by 1 author, the primary author.

## 2.5 | Outcomes

The outcome of interest was to determine if there was an increased risk of presenting with complicated appendicitis during COVID social distancing compared to the prior year.

## 2.6 | Analysis

Associations between the COVID-19 and non-COVID-19 eras and complexity of appendicitis cases were analyzed using t-tests for contin-

**TABLE 1** Demographics

Total (n = 507)	Pre-COVID (n = 249)	COVID (n = 258)	P value
Age, y (mean ± SD)	10.49 ± 3.41	10.36 ± 3.70	0.69
Gender			
Male	146 (58.6)	138 (53.5)	0.24
Female	103 (41.4)	120 (46.5)	
Race/ethnicity			
White	86 (34.7)	91 (35.7)	0.73
Hispanic	142 (57.3)	139 (54.5)	
Other <sup>a</sup>	20 (8.0)	25 (9.8)	
Insurance status			
Commercial	103 (41.4)	122 (47.3)	0.39
Public	127 (51.0)	120 (46.5)	
Self-pay	19 (7.6)	16 (6.2)	
COVID status (positive or negative)	0	9: 222 (36 unknown)	

<sup>a</sup>There is a discrepancy in the totals as 4 patients were missing data on race/ethnicity.

uous normally distributed data and  $\chi^2$  analysis and Fisher's exact test for categorical variables using STATA version 12. For those continuous variables not normally distributed, Wilcoxon rank-sum test was used to compare the COVID-19 and non-COVID-19 eras. Means are presented as means ± SD. A 2-sample test of proportions was used to compare proportion of appendicitis per emergency department (ED) admission before and during COVID. Univariate and multivariate logistic regression was performed to assess the odds of receiving a computed tomography (CT) scan in the COVID time period compared to the pre-COVID time period.

## 3 | RESULTS

### 3.1 | Characteristics of study subjects

Our study consisted of a total of 507 cases of appendicitis between the 2 time periods of interest with 249 patients in the non-COVID-19 era and 258 patients in the COVID-19 era. The total ED visits during each time period were 71,195 and 40,160, respectively. The proportion of children in the ED treated for appendicitis was 0.3% pre-COVID versus 0.6% during the COVID time period ( $P = 0.6149$ ). There were no statistically significant differences between the time periods in terms of gender distribution or race/ethnicity as seen in Table 1. Similarly, there were no statistically significant differences in the insurance status of patients also demonstrated in Table 1.

### 3.2 | Main results

Almost all 507 patients were managed surgically with appendectomies, except for 2 in 2019 versus 3 in 2020 that were managed medically

**TABLE 2** Evaluation and treatment for pediatric appendicitis during the COVID-19 pandemic

Column1	Pre-COVID (n = 249)	COVID (n = 258)	P-value
Required CT			
Yes	88 (35.3)	121 (46.9)	0.008
No	161 (64.7)	137 (53.1)	
Duration of symptoms on presentation, h, median (IQR)	24 (15–48)	24 (24–48)	0.27
Duration of symptoms on presentation			
<24 h	116 (54.7)	144 (57.1)	0.60
>24 h	96 (45.3)	108 (42.9)	
Complicated			
Yes	74 (30.0)	83 (32.2)	0.59
No	173 (70.0)	175 (67.8)	
Trips to the OR			
0 or 1	237 (96.3)	254 (98.5)	0.14
2 or more	9 (3.7)	4 (1.6)	
Received appendectomy			
Yes	247 (99.2)	255 (98.8)	0.52
No	2 (0.8)	3 (1.2)	
Appendectomy type			
Laparoscopy	244 (99.2)	253 (99.2)	1
Open	1 (0.4)	1 (0.4)	
Laparoscopy converted to open	1 (0.4)	1 (0.4)	
ED LOS, h, mean $\pm$ STD	256.3 $\pm$ 108.4	267.7 $\pm$ 106.4	0.24
LOS, days, median (IQR)	0 (0–3)	0 (0–3)	0.38
Pathology findings			
Acute			
YES	164 (65.9)	184 (71.3)	0.19
NO	85 (34.1)	74 (28.7)	
Gangrenous/necrotizing			
YES	38 (15.3)	29 (11.2)	0.18
NO	211 (84.7)	229 (88.8)	
Micro perforation			
YES	13 (5.2)	18 (7.0)	0.41
NO	236 (94.8)	240 (93.0)	
Perforation			
YES	53 (21.3)	49 (19.0)	0.52
NO	196 (78.7)	209 (81.0)	
Operative findings			
Acute			
YES	167 (67.1)	160 (62.0)	0.24
NO	82 (32.9)	98 (38.0)	
Gangrenous/necrotizing			
YES	19 (7.6)	18 (7.0)	0.78
NO	230 (92.4)	240 (93.0)	

(Continues)

**TABLE 2** (Continued)

Column1	Pre-COVID (n = 249)	COVID (n = 258)	P-value
Micro perforation			
YES	70 (28.1)	80 (31.0)	0.48
NO	179 (71.9)	178 (69.0)	
Abscess			
YES	15 (6.0)	24 (9.3)	0.17
NO	234 (94.0)	234 (90.7)	
Complicated appendix parameters			
Visible perforation			
YES	65 (26.1)	74 (28.7)	0.52
NO	184 (73.9)	184 (71.3)	
Abscess			
YES	16 (6.4)	25 (9.7)	0.18
NO	233 (93.6)	233 (90.3)	
Diffuse fibrinopurulent exudate			
YES	33 (13.3)	10 (3.9)	<0.001
NO	216 (86.8)	248 (96.1)	
Extraluminal fecalith			
YES	3 (1.2)	1 (0.4)	0.3
NO	246 (98.8)	257 (99.6)	
PICU admission			
YES	2 (0.8)	3 (1.2)	0.68
NO	247 (99.2)	255 (98.8)	
Post-operative complications			
Wound infection			
YES	1 (0.4)	1 (0.4)	1
NO	246 (99.6)	254 (99.6)	
Intra-abdominal abscess			
YES	9 (3.6)	7 (2.8)	0.62
NO	238 (96.4)	248 (97.3)	
Bowel obstruction			
YES	1 (0.4)	1 (0.4)	1
NO	245 (99.6)	254 (99.6)	
DVT			
YES	0 (0.0)	0 (0.0)	
NO	0 (0.0)	0 (0.0)	
Bleeding requiring transfusion			
YES	2 (0.8)	0 (0.0)	0.24
NO	245 (99.2)	255 (100.0)	
Damage to nearby structure			
YES	0 (0.0)	1 (0.4)	1
NO	247 (100.0)	254 (99.6)	
Pneumonia			
YES	0 (0.0)	1 (0.4)	1
NO	247 (100.0)	254 (99.6)	

(Continues)

**TABLE 2** (Continued)

Column1	Pre-COVID (n = 249)	COVID (n = 258)	P-value
Needed post-operative IR			
YES	7 (2.8)	2 (0.8)	0.1
NO	240 (97.2)	253 (99.2)	
Needed post-operative operation			
YES	2 (0.8)	2 (0.8)	1
NO	244 (99.2)	253 (99.2)	

**TABLE 3** Imaging used by year

Modality	2019	2020	Total
Ultrasound only	151	130	281
CT only	29	43	72
Both modalities	59	78	137
Total	239	251	490

with either intravenous antibiotics alone or intravenous antibiotics and IR drainage ( $P = 0.52$ ). All procedures were laparoscopic, except for 1 in each year requiring an open appendectomy and 1 in each year requiring conversion to an open procedure ( $P = 1.00$ ). There was no significant difference in complicated appendicitis rates as defined intraoperatively with 74 (30%) in 2019 and 83 (32.2%) patients meeting criteria ( $P = 0.59$ ). Pathology results between both time periods were also similar as seen in Table 2 with most cases being acute of 65.9% versus 71.3% ( $P = 0.19$ ) in 2019 versus 2020, 21.3% versus 19% perforated ( $P = 0.52$ ), 15.3% versus 11.2% gangrenous/necrotizing ( $P = 0.18$ ), and 5.2% versus 7% microperforated ( $P = 0.41$ ). Operative findings were also similar between the 2 time periods with 67.1% versus 62% acute ( $P = 0.24$ ), 6% versus 9.3% with abscesses ( $P = 0.17$ ), 7.6% versus 7% gangrenous/necrotizing ( $P = 0.78$ ), and 28.1% versus 31% microperforated ( $P = 0.48$ ).

There was no significant delay in presentation found during the COVID era. There was a statistically significant increase in the use of CT scans with 121 patients (46.9%) in 2020 undergoing CT scan compared to 88 patients (35.3%) ( $P = 0.008$ ) in 2019. Patients were more likely to have both an ultrasound and CT scan ( $P = 0.036$ ) in the COVID-19 era as seen in Table 3. After adjusting for patient-level factors, children presenting to the ED for appendicitis during COVID were 1.81 times more likely to receive a CT scan as seen in Table 4.

Intraoperative and postoperative complications were rare in both time periods with few patients experiencing damage to nearby structures (1 in 2020), bleeding requiring transfusion (2 in 2019), bowel obstruction (1 in each year), wound infection (1 in each year), pneumonia (1 in 2020) as seen in Table 2 with postoperative intraabdominal abscesses being the more common, albeit still rare complication, seen in 9 patients (3.6%) in 2019 versus 7 patients (2.8%) in 2020 ( $P = 0.62$ ). Only 2 patients in each year required an additional operation and postoperative IR procedures occurred in 7 patients (2.8%) in 2019 ver-

sus 2 patients (0.8%) in 2020. We were unable to assess the effect of SARS-CoV-2 status on outcomes due to the low number of infections diagnosed in the COVID-19 era with only 9 patients testing positive.

#### 4 | LIMITATIONS

Our study has a variety of limitations to consider as it was conducted at a single-center site, in addition to the limitations experienced with any retrospective analysis. In comparison to previously published studies on this subject, our study was conducted in a different region of the world, and even more so, a distinct region of the United States that experienced a rise in cases more variably compared to the northeast region of the United States that experienced a catastrophic surge in cases earlier than the rest of the country. Additionally, the particular time period analyzed in our data was outside of the regional surge of cases seen in the southeastern portion of the United States. A broader period of data collection may have further demonstrated more frequent cases of severe presentations of appendicitis in patients and thus, possibly, more complications. The aforementioned studies indicated that the highest rates of complications, including perforations, were seen during their respective regional surge which we may have demonstrated with a larger period of data collection.

#### 5 | DISCUSSION

Compared to previous studies in the adult and pediatric literature showing delays in seeking medical care in the setting of the COVID-19 era, our study found no statistically significant delay in care compared to pre-COVID. In addition, our study did not find an increased rate of complicated appendicitis case presentations according to the operative definition. Although perforation and pre-operative abscess rates were seen at slightly higher rates in the COVID-19 era compared to the non-COVID-19 era, these results did not reach statistical significance. The need for PICU admission was similar between the 2 time periods and overall rates of postoperative complications were found to be comparable. Postoperative complications such as intra-abdominal abscess, bowel obstruction, and bleeding requiring transfusion were seen even less frequently, and rare complications like pneumonia and damage to nearby structures were found only to occur in 1 individual in

**TABLE 4** Odds of CT scan usage pre- and post-COVID

Univariate	Pre-COVID (n = 249)	COVID (n = 258)	95% CI	P-value
Required CT	1.0 (referent)	OR = 1.62	1.13–2.31	0.008
Multivariate	Pre-COVID (n = 249)	COVID (n = 258)	95% CI	P-value
Required CT	1.0 (referent)	OR = 1.81	1.21–2.69	0.004
Duration of symptoms		OR = 0.85	0.58–1.25	0.403
Gender		OR = 0.99	0.68–1.44	0.941
Race/ethnicity		OR = 1.10	0.70–1.73	0.680
Insurance status		OR = 0.78	0.51–1.21	0.272
Age, y		OR = 0.97	0.92–1.02	0.217

Abbreviations: CI, confidence interval; COVID, coronavirus disease; CT, computed tomography; OR, odds ratio.

the COVID-19 era when compared to the prior year. These important convergent findings to the literature could be interpreted that delay in care and subsequent increased complication rates of appendicitis during COVID are not generalizable and may differ by region and/or hospital system.

In the various studies we looked at, complicated appendicitis was described as an operative finding with a few studies defining complicated appendicitis histopathologically. Operatively, complicated appendicitis was defined by the presence of a phlegmonous or perforated appendix and/or peri-appendicular abscess formation with only 2 studies considering complicated appendicitis as pus, gangrene, or perforation on histopathology.<sup>10</sup> Our study defined complicated appendicitis as findings of abscess, visible perforation, extraluminal fecalith, diffuse fibrinopurulent exudate discovered either operatively or histopathologically.

A small study in Israel comparing March 1 to April 30, 2020 to the same time period in 2019, with n = 81 and n = 80, respectively, demonstrated a consistent delay in presentation with all 7 cases of patients presenting at >48 hours from symptom onset. With this delay, their study found that the complication rate was twice as high in the COVID-19 period when compared to the prior year, approaching statistical significance (P-value = 0.06).<sup>16</sup> Another study in Australia comparing the time period of March 16 to May 5 in 2019 and 2020, with n = 57 and n = 48, respectively, demonstrated an increase in complicated appendicitis twice as high during the pandemic compared to a similar time frame the prior year.<sup>17</sup> A study out of New York City, the initial epicenter of the outbreak in the United States, comparing March 1 to May 7, 2020 to the previous 5-year control period prior to the pandemic, with n = 55 compared to n = 1291, respectively, also demonstrated a significantly higher perforation rate that was similar to other international studies, and additionally, patients who presented with longer duration of symptoms had higher rates of perforations when compared to historical controls. Outcomes were not found to be inferior in patients with a preoperative diagnosis of SARS-CoV-2 with no difference in perforation rates seen between those with or without COVID-19.<sup>18</sup> Each study found parental concern and fear of contracting COVID-19 to be a major hindrance for families to seek care in the time of the pandemic.

All of these studies were based on a relatively small sample of patients over a narrower time period of interest possibly leading to time period bias. These previous studies in this area were all fairly small with few numbers of COVID cases.

There are notable comparisons between our study and the aforementioned studies. Similar to our site, all of these studies took place in large children's hospitals with access to tertiary care pediatric specialty and subspecialty services. In addition, like most hospitals, our site restricted surgical services to only those requiring emergent care and staff was brought in as needed with no restrictions on the promptness of procedures. It is difficult to surmise if the aforementioned studies were limited in staffing and timeliness to provide care for emergent or urgent surgical needs and whether or not this may have contributed to the increased rates of complications seen. However, in comparison to our study, the above referenced studies were much smaller in sample size and in duration of weeks of comparison during each time period. The larger number of patients and time period observed in our study may have provided more power to demonstrate the lack of increased complication rates seen between the 2 time periods observed. The longer duration may have also provided more insight into the ebb and flow of the pandemic seen in the region of Central Texas with parents and guardians possibly feeling more confident in seeking medical attention for their child in a timely manner when rates of COVID-19 in the community were down. Perhaps a further breakdown into the time period we observed could demonstrate even more of an effect on the data when evaluated during the peaks and troughs of the pandemic.

Interestingly, our study did demonstrate a statistically significant increase in the use of CT imaging for the diagnosis of appendicitis. Radiation use in the pediatric population can lead to harmful effects on the growing child and it is not the initially preferred diagnostic tool to diagnose pathology.<sup>19,20</sup> Despite low-dose settings in most pediatric tertiary care centers, other diagnostic modalities are favored. Although, the CT scan remains the gold standard of care in diagnosing appendicitis,<sup>21</sup> at our institution, we use the pediatric appendicitis score as an excluding tool in conjunction with an ultrasound as the primary modality of diagnosing appendicitis. We reserve the use of CT scans for inconclusive cases.



As demonstrated by Table 3, there was a higher use of CT scans for diagnostic confirmation of appendicitis in the COVID-19 era when compared to data from the prior year. The data analysis showed a statistically significant increase in the likelihood that a patient would have both ultrasound and CT in the COVID-19 time period when compared to the pre-pandemic era.

The increased use of CT scans could be due to many different factors. The technical skill of an ultrasound technician can lead to variability in skills between sonographers. Our institution had a high rate of staff turnover throughout the pandemic. This phenomenon was seen across the country and may have led to a varying degree of experience and expertise in obtaining adequate images to allow the radiologist to confirm a diagnosis of appendicitis.<sup>22</sup> Operator error may have played a role in requiring further diagnostic confirmation. Studies where the appendix was not seen or characteristics of the images were found to be equivocal likely led to the physician ordering a CT scan to further confirm the diagnosis and reduce any uncertainty.

Additionally, one could surmise that this may have been due to an increased severity in the clinical presentation of the patient. However, when looking at the rates of complicated appendicitis or other clinical complications, it is unlikely that this is the case. Rather, the higher use of CT scans may have been due to the surgeon requiring a higher degree of certainty in the diagnosis with a requirement of imaging confirmation before taking the patient to the operating room. The risk of exposing hospital staff to the coronavirus unless absolutely necessary has certainly been something to consider in the time of the pandemic.

Although our study did not demonstrate an increased risk of complicated appendicitis in the COVID-19 era, the significance of this study may be in the observed increased use of CT scans in a population of patients known to be at increased risk for future lethal malignancy due to the harmful effects of radiation. The choice to do no harm can become convoluted in complicated circumstances, such as a pandemic, where diagnostic differentiation between appendicitis and a new and poorly understood high risk viral infection can lead to changes in care that can negatively impact the overall health of a pediatric patient. It is hard to know whether or not 1 CT scan will always lead to such detrimental complications, but if this in fact was a broader trend seen around the world at sites caring for pediatric patients, this may lead to a future public health crisis as not only has the pandemic put numerous stressors on children and adolescents' mental health but worse, lead to future lethal malignancy.

Finally, our limited knowledge of the novel coronavirus and its implications early in the pandemic may have led to an element of fear among the physicians, non-physician healthcare practitioners and staff caring for patients presenting to the ED. As healthcare workers on the front line in the middle of a pandemic, there had to be a conscious choice every day to willingly expose oneself to a deadly virus and to risk support staff being exposed to COVID-19 as well. Most operating rooms were shut down and only opened for absolute emergent procedures potentially contributing to the need for a more definitive diagnosis prior to a high risk procedure that could lead to exposure and transmission of this virus.<sup>23</sup> This reality along with the well described frustrations of healthcare workers experiencing prolonged work hours

and limited access to PPE led to hospitals having to be discriminatory in their use of resources in such an uncertain time. The pandemic has caused a significant loss of life globally and a recently published study from Kaiser Health News found that over 3600 US health care workers died in the first 12 months of the COVID-19 pandemic with nurses and support staff members dying in far higher numbers than physicians.<sup>24</sup> These numbers are not insignificant and demonstrate the high toll that coronavirus has had on the healthcare staff in addition to the strain felt by the inundation of patients requiring care and hospitalization.

It is difficult to extrapolate the reasoning for these findings without further qualitative investigation of the motivations of pediatric emergency medicine physicians and surgeons in their increased use of CT scans. This trend did not seem to be affected by whether or not the patient had a diagnosis of COVID-19. Further studies could seek to survey surgeons and ED physicians regarding their various changes in practices during the pandemic.

The COVID-19 pandemic has had an impact on timely presentations of pediatric patients to emergency departments with a delay in presentation demonstrated in this study.<sup>25</sup> Complication rates were not necessarily higher in this single-center sample of patients when compared to the prior year. CT scan use increased during the pandemic. Further research should be conducted to assess broader patterns, both nationally and globally, to determine the full impact that the pandemic has had on severity of pediatric presentations, complications, and altered practices in use of various imaging modalities.

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