

Oregon Health & Science University  
School of Medicine

**Scholarly Projects Final Report**

**Title** *(Must match poster title; include key words in the title to improve electronic search capabilities.)*

Impact of the COVID-19 Pandemic on Management and Outcomes of Pediatric Appendicitis

**Student Investigator's Name**

Ashraf Samhan

**Date of Submission** *(mm/dd/yyyy)*

03/10/2023

**Graduation Year**

2023

**Project Course** *(Indicate whether the project was conducted in the Scholarly Projects Curriculum; Physician Scientist Experience; Combined Degree Program [MD/MPH, MD/PhD]; or other course.)*

Scholarly Projects Curriculum

**Co-Investigators** *(Names, departments; institution if not OHSU)*

Meredith Kato, MD, Department of Anesthesiology and Perioperative Medicine

**Mentor's Name**

Meredith Kato, MD

**Mentor's Department**

Anesthesiology and Perioperative Medicine

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## Concentration Lead's Name

Lisa Silbert, MD

## Project/Research Question

Do pediatric patients with acute appendicitis who undergo appendectomy during the COVID-19 pandemic experience longer hospital stays compared to the pre-pandemic era?

## Type of Project *(Best description of your project; e.g., research study, quality improvement project, engineering project, etc.)*

Research study

## Key words *(4-10 words describing key aspects of your project)*

COVID-19, SARS-CoV-2, acute appendicitis, complicated appendicitis, pediatrics, pandemic

## Meeting Presentations

*If your project was presented at a meeting besides the OHSU Capstone, please provide the meeting(s) name, location, date, and presentation format below (poster vs. podium presentation or other).*

N/A

## Publications *(Abstract, article, other)*

*If your project was published, please provide reference(s) below in JAMA style.*

N/A

## Submission to Archive

*Final reports will be archived in a central library to benefit other students and colleagues. Describe any restrictions below (e.g., hold until publication of article on a specific date).*

N/A

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## Next Steps

*What are possible next steps that would build upon the results of this project? Could any data or tools resulting from the project have the potential to be used to answer new research questions by future medical students?*

- Investigating changes in the frequency of non-operative management of acute appendicitis
- Understand factors that contributed to increased time from initial presentation to appendectomy
- Comparing incidence of complicated appendicitis with other regions in the US vs other countries

**Please follow the link below and complete the archival process for your Project in addition to submitting your final report.**

**[https://ohsu.ca1.qualtrics.com/jfe/form/SV\\_3ls2z8V0goKiHZZ](https://ohsu.ca1.qualtrics.com/jfe/form/SV_3ls2z8V0goKiHZZ)**

**Student's Signature/Date** *(Electronic signatures on this form are acceptable.)*

*This report describes work that I conducted in the Scholarly Projects Curriculum or alternative academic program at the OHSU School of Medicine. By typing my signature below, I attest to its authenticity and originality and agree to submit it to the Archive.*

X

Ashraf Samhan

Student's full name

**Mentor's Approval** *(Signature/date)*

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**Report:** *Information in the report should be consistent with the poster, but could include additional material. Insert text in the following sections targeting 1500-3000 words overall; include key figures and tables. Use Calibri 11-point font, single-spaced and 1-inch margin; follow JAMA style conventions as detailed in the full instructions.*

## Introduction

Acute appendicitis (AA) is the most frequent cause of emergency abdominal surgery in children. It is categorized as uncomplicated and complicated, with the latter subtyped into peri-appendiceal abscess formation, gangrene, phlegmon, peritonitis, and/or perforation<sup>1</sup>. In March 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic, requiring governments to implement periods of mandatory lockdown in hopes of minimizing viral transmission<sup>2</sup>. The risk of COVID-19 to children was unclear during the early period of the pandemic. Nonetheless, the fear of contracting COVID-19 caused parents and children to avoid seeking care, leading to delays in presentation and subsequent treatment<sup>3</sup>. A study conducted in the United States found a dramatic decline in acute appendicitis, possibly due to changes in social behavior or spontaneous resolution of symptoms<sup>4</sup>. Furthermore, the pandemic altered surgical practice that limited operative interventions to urgent conditions. While appendectomy is the first-line treatment, conservative management with antibiotics has emerged as a potential therapy for uncomplicated AA in hopes of preserving hospital capacity. However, a review of the current literature suggests that there is no consensus regarding the impact of the pandemic on pediatric appendicitis.

In our single-center study, we aimed to examine the effects of the pandemic on the management and outcomes of pediatric appendicitis over a six-month period. Specifically, we evaluated for possible differences in the length of hospital stay, rates of complicated appendicitis, and time from admission to appendectomy. We hypothesized that there would be increased rates of complicated appendicitis and delays in presentation compared to a similar pre-pandemic period.

## Methods

The study was conducted with the approval of our local institutional review board. A waiver of informed consent was granted.

We performed a retrospective, single-center cohort study of children less than 18 years old at the time of hospital admission who were diagnosed and treated for AA at Oregon Health and Science University (OHSU) from April 2019 to September 2020. Patients were divided into two groups: those treated before the pandemic (April 1, 2019 – September 30, 2019) and those treated during the pandemic (April 1, 2020 – September 30, 2020). Exclusion criteria were age 18 or older, absence of histological diagnosis of AA, and diagnosis and surgical intervention outside of the above time periods. We compared demographic characteristics, type of appendicitis (i.e. uncomplicated vs complicated), time of symptom onset, mean length of hospitalization, ASA score, and need for postoperative drain placement.

The diagnosis of AA was diagnosed by clinical examination, laboratory testing, and abdominal imaging. All patients underwent laparoscopic appendectomy. The final diagnosis of AA was confirmed histopathologically.

Data was collected in Microsoft Excel 2017 and analyzed with SPSS Statistics v26. Baseline differences were tested using two-sided unpaired t-tests for comparison of means. The normality of variables was analyzed by Shapiro-Wilk testing. Categorical variables were expressed as a percentage (%) and were analyzed by Chi-square test. Non-parametric continuous variables were analyzed by the Mann-Whitney U test. All statistical calculations were performed with two tails and the statistical significance was established with a value of  $p < 0.05$ .

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## Results

A total of 196 patients (56.6% female), comprised of 110 (56.1%) with AA and underwent appendectomy prior to the pandemic and 86 (43.9%) during the pandemic were included for analysis. There were no significant demographic differences between the pre-pandemic and the COVID-era group in terms of mean age, sex, and ethnicity (Table 1). The mean symptom duration prior to presentation was also similar (1.7 vs 1.59 days,  $p = 0.70$ ).

**Table 1.** Baseline demographics of patients with acute appendicitis before and during the COVID-19 pandemic.

	Pre-COVID (n=110)	During COVID (n=86)	P-value
<b>Age (years)</b>			
Mean	10.11	10.93	0.16
Range	1-17	2-17	
<b>Sex (%)</b>			
Male	53.7%	58.1%	0.53
Female	46.3%	41.9%	
<b>Ethnicity (%)</b>			
Non-Hispanic	73.7%	61.5%	0.07
Hispanic	27.3%	39.5%	

During the COVID-19 pandemic, there was a higher proportion of complicated appendicitis (50% vs 34.5%,  $p = 0.03$ ) (Table 2). The perforation rate was greater in the pandemic cohort (43% vs 24.5%,  $p = 0.006$ ), however, there were no differences in gangrenous (18.6% vs 14.5%,  $p = 0.45$ ) or peri-appendicular abscess formation (9.1% vs 7.0%,  $p = 0.59$ ).

In the COVID-era cohort, there was an approximately five-hour delay from admit time to appendectomy (16.9 vs 22,  $p < 0.0001$ ). Length of hospitalization was also longer in the COVID-era group (4.25 vs 2.82 days,  $p = 0.002$ ). There was a higher rate of post-operative drain placement, but this was not statistically significant (5.8% vs 2.7%,  $p = 0.28$ ).

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**Table 2.** Comparison of clinical outcomes of patients with acute appendicitis who underwent appendectomy before and during the COVID-19 pandemic.

	Pre-COVID (n=110)	During COVID (n=86)	P-value
<b>Mean LOS (days)</b>	2.82	4.25	0.002
<b>Mean symptom duration prior to presentation (days)</b>	1.70	1.59	0.70
<b>Mean initial WBC (10<sup>3</sup>/mL)</b>	15.32	14.77	0.43
<b>ASA score (%)</b>			
1-2	92.7%	94.2%	0.87
3-4	7.3%	5.8%	
<b>Mean admit time to surgical incision (hours)</b>	16.93	22	<0.0001
<b>Type of Appendicitis (%)</b>			
Uncomplicated	65.5%	50%	0.03
Complicated	34.5%	50%	
<b>Types of Complicated Appendicitis (%)</b>			
Perforated	24.5%	43.0%	0.006
Gangrenous	14.5%	18.6%	0.45
Periappendiceal abscess	9.1%	7.0%	0.59
<b>Post-operative drain placement (%)</b>	2.7%	5.8%	0.28

## Discussion

Acute appendicitis is one of the common surgical indications in the pediatric population. In this single-center, retrospective study of pediatric patients with acute appendicitis, we found increased rates of perforated appendicitis and longer lengths of hospitalizations during the COVID-19 pandemic. Furthermore, there was a prolonged duration from admission time to surgical incision in the COVID-era cohort. There was no significant difference in the duration of symptoms prior to presentation. Lastly, we observed an increase in post-operative drain placement, although was not statistically significant.

Our findings have several similarities compared to previously published studies. A small study conducted in Australia's largest children's hospital observed a two-fold increase in complicated appendicitis during the pandemic<sup>6</sup>. Snapiri *et al.* reported a series of seven perforated pediatric appendicitis during the early pandemic period in Israel, which identified delays in diagnosis felt secondary to parental concern regarding viral exposure and insufficient medical evaluation<sup>7</sup>. In the U.S., Place *et al.* reported higher rates of appendiceal perforation over a 3-month period in Virginia. Gerall *et al.* evaluated rates of complicated appendicitis and length of hospital stay over 3-month periods pre- and intra-pandemic in 89 patients in New York and found significantly longer median duration of symptoms prior to presentation (2 vs 1 day), increased rates of perforations (41.7% vs 9.8%), longer median length of hospital stay (2 vs 1 day)<sup>8</sup>. Notably, these studies had smaller sample sizes and narrower time periods of interest compared to our study. In contrast, Theodorou *et al.* found no difference in perforation rates (40.4% vs 42.1%), however, also

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reported a longer median length of stay (2 vs 3 days) over a 6-month period across four hospitals in California<sup>9</sup>. Important to note, the investigated period was not during a COVID surge, which is different from the aforementioned New York study.

We found that the COVID-era cohort experienced longer LOS compared to the pre-COVID group. Our investigation showed no significant delay in diagnosis to explain the increase in complicated cases or LOS. We suspect that the increase in LOS is related to hospital-instituted, mandatory pre-operative COVID-19 screening. Another potential reason is the logistical challenges in navigating surgical care within hospitals overwhelmed with illnesses, including adequate staffing and protecting personnel with personal protective equipment, which may contribute to delays from admission to surgical intervention and consequently LOS. Our study was conducted during the early pandemic period in Oregon, at which time there was limited knowledge of the virus' implications. Hospitals were strained for resources and operating rooms were limited to emergent procedures to minimize the risk of viral transmission.

Our study has several limitations, including its retrospective design and small sample size. However, relative to other studies, we investigated outcomes using longer time intervals (3 months vs 6 months) and larger populations for both groups. We only investigated outcomes in patients diagnosed with AA that were treated surgically. Future studies include assessing changes in non-operative management, examining the factors that contributed to delays in surgical intervention, and investigating the impact of socioeconomic background on time to presentation and outcomes.

### Conclusions

Current literature demonstrates mixed data regarding the incidence of complicated appendicitis and length of hospital stay during the COVID-19 pandemic. The results of this single-center study depict a higher incidence of pediatric complicated acute appendicitis, longer delays to appendectomy, and prolonged hospitalizations despite no significant differences in symptom duration during the pandemic period.

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## References

1. Addiss DG, Shaffer N, Fowler BS, Tauxe RV. The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiol.* 1990 Nov;132(5):910-25.
2. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. *Acta Biomed.* 2020 Mar 19;91(1):157-160.
3. Kumaira Fonseca M, Trindade EN, Costa Filho OP, Nácul MP, Seabra AP. Impact of COVID-19 Outbreak on the Emergency Presentation of Acute Appendicitis. *Am Surg.* 2020 Nov;86(11):1508-1512.
4. Rosenthal, Martin G. MD; Fakhry, Samir M. MD; Morse, Jennifer L. MS et al. Where Did All the Appendicitis Go? Impact of the COVID-19 Pandemic on Volume, Management, and Outcomes of Acute Appendicitis in a Nationwide, Multicenter Analysis. *Annals of Surgery Open* 2(1):p e048, March 2021.
5. Köhler F, Müller S, Hendricks A, Kastner C, Reese L, Boerner K, Flemming S, Lock JF, Germer CT, Wiegering A. Changes in appendicitis treatment during the COVID-19 pandemic - A systematic review and meta-analysis. *Int J Surg.* 2021 Nov;95:106148.
6. Lee-Archer P, Blackall S, Campbell H, Boyd D, Patel B, McBride C. Increased incidence of complicated appendicitis during the COVID-19 pandemic. *J Paediatr Child Health.* 2020 Aug;56(8):1313-1314.
7. Snapiri O, Rosenberg Danziger C, Krause I, Kravarusic D, Yulevich A, Balla U, Bilavsky E. Delayed diagnosis of paediatric appendicitis during the COVID-19 pandemic. *Acta Paediatr.* 2020 Aug;109(8):1672-1676.
8. Gerall CD, DeFazio JR, Kahan AM, Fan W, Fallon EM, Middlesworth W, Stylianos S, Zitsman JL, Kadenhe-Chiweshe AV, Spigland NA, Griggs CL, Kabagambe SK, Apfel G, Fenster DB, Duron VP. Delayed presentation and sub-optimal outcomes of pediatric patients with acute appendicitis during the COVID-19 pandemic. *J Pediatr Surg.* 2021 May;56(5):905-910.
9. Theodorou CM, Beres AL, Nguyen M, Castle SL, Faltermeier C, Shekherdimian S, Tung C, DeUgarte DA, Brown EG. Statewide Impact of the COVID Pandemic on Pediatric Appendicitis in California: A Multicenter Study. *J Surg Res.* 2021 Nov;267:132-142.