

## Impact of the COVID-19 Pandemic on Elective and Emergency Pediatric Surgeries: A Single-Center Experience in a Tertiary Center in Iran

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### Abstract

**Background:** The COVID-19 pandemic has disrupted healthcare systems globally, leading to the suspension of many elective surgeries. The impact of the pandemic on pediatric surgical care in tertiary centers is not well understood. This retrospective study aims to examine the effect of COVID-19 on the management of surgical diseases in children.

**Methods:** A retrospective single-center cross-sectional study was performed to collect information on the children who were operated either emergently or in an elective setting. The demographics, field of surgery, outcomes, and the rates of mortality and morbidity were measured. Moreover, this study evaluated the associations between coronavirus disease 2019 (COVID-19) infection and surgical outcomes and length of hospital stay.

**Results:** A total of 1028 children were included in the study with an average age of  $60.51 \pm 50.3$  months. Only 33 children (3.2%) were positive for COVID-19 during the admission days. Moreover, 87 (8.5%) patients developed pulmonary, gastrointestinal, or infectious complications, and 22 patients (2.5%) expired. Morbidity was significantly associated with the presence of COVID-19 infection ( $p < 0.001$ ). Furthermore, the rate of complications was much higher in patients who underwent emergency operations ( $p < 0.001$ ). In addition, mortality in positive cases was remarkably higher than that in negative cases (22.2% vs. 1.9%,  $p < 0.001$ ).

**Conclusion:** The overall rates of complications, morbidity, and mortality were much higher in emergency operations compared to elective surgeries. Also, the presence of COVID-19 infection in this population led to more cases of morbidity.

**Key Words:** Elective Surgeries, Novel Coronavirus 2019, Pediatrics, SARS-CoV-2, Surgery.

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## 1- INTRODUCTION

After the first cases of human infection by the novel coronavirus in China were confirmed, it quickly spread throughout the world (1). In Iran, a Middle Eastern country, the coronavirus disease 2019 (COVID-19) pandemic officially started after the detection of the first death associated with the virus on February 19, 2020 (2). From that date, governmental decisions changed the normal life of individuals. Lockdowns, curfews, mandatory personal protective equipment, and skyrocketing death rate led to countrywide fear and panic (3). Moreover, overwhelming medical visits and growing admissions caused overtiredness and burnout in medical staff. For this reason, many non-urgent surgeries were suspended in numerous countries (4, 5). In Iran, due to National Health Organization guidelines, elective surgeries were suspended or significantly reduced (6, 7). Many studies report the impacts of COVID-19 on surgeries, complications, morbidity and mortality in Iran. Almost every subspecialty announced the increasing rate of delayed diagnoses, non-timely treatments, and catastrophic complications (8-12). Nevertheless, these reports did not focus on operations in the pediatric population. Therefore, this study aimed to review and share the experience in the management of pediatric surgeries during the COVID-19 pandemic. In addition, this study evaluated the effects of the pandemic and the virus on emergency or elective surgeries and their complications and outcomes.

## 2- MATERIALS AND METHODS

### 2-1. Study design

This retrospective single-center cross-sectional study included all the children who underwent surgery during the COVID-19 pandemic. We aimed to collect information about the field of surgeries, distribution of genders, morbidity and

mortality, the incidence of COVID-19 and its impact on patients' outcome. The impact of COVID-19 on elective or emergency surgeries was also investigated.

### 2-2. Design and population

This retrospective cross-sectional study was conducted at Mofid Children's Hospital, a tertiary center in Tehran, Iran. As one of the most prominent pediatric surgery centers in Iran, almost all kinds of operations in various fields are performed routinely in our center. We reviewed and analyzed all the data from the patients who underwent surgery within March 2020 to March 2021 (i.e., concomitant with the first and second waves of COVID-19 in Iran (13)).

During the pandemic, most elective operations were stopped for a short period. Afterwards, institutional and countrywide protocols were developed to restart elective and less emergent operations. Given that our institute is a university-affiliated medical center, this study followed their integrated guidelines for starting elective surgeries during the COVID-19 pandemic. For investigations on COVID-19 infection, several screening methods, such as polymerase chain reaction (PCR), low-dose lung computed tomography (CT), measuring serum inflammatory biomarkers, and conventional chest X-ray, were allowed.

Due to the overwhelming burden of COVID-19 on the healthcare system, and the growing rate of admissions, and the lack of hospital beds, surgeries were divided into two distinct groups, namely elective and emergency procedures.

Elective operations for stable patients were postponed until observing further notices for surgery. However, for those who waited a long time, a PCR test was performed three days before the surgery. On the other hand, due to the lack of rapid antigen tests, emergency cases were screened using other screening tools. Low-

dose lung CT was utilized in less urgent patients who could wait for at least 6 hours. However, a combination of laboratory data and chest X-rays is implemented in more emergent cases. These laboratory data included complete blood count, erythrocyte sedimentation rate, and C-reactive protein. Moreover, in unstable conditions (e.g., multiple traumas, ongoing bleeding, and aspirated foreign bodies), the child was taken to the operating room without delay. Additionally, all emergency cases (including both screened and unscreened) were, initially, considered positive for COVID-19 infection. Therefore, the operation setting was adjusted with disposable devices, filtered airways, and extra personal care protocols.

### 2-3. Inclusion and exclusion criteria

All the children under 18 years of age who underwent any kind of surgery were enrolled in the study. However, patients with incomplete records, missing data, and unknown procedures were not included.

### 2-4. Data gathering

Data collection was performed by reviewing and retrieving electronic medical records. Demographics, surgical field, surgery type, screening method, COVID-19 symptoms, and outcomes of the cases were extracted from the records, and imported into an electronic dataset. This process was carried out by medical students, residents, and fellows.

### 2-5. Data analysis

We analyzed the acquired data using Statistical Package for the Social Sciences (SPSS), version 26 (IBM, Armonk, NY). For continuous variables such as age and length of hospital stay, we used mean, and standard deviation to show the amount of central tendency or dispersion, respectively. On the other hand, for categorical variables, such as gender, the frequency was used. In addition, Chi-

square test, and t-tests were employed for categorical and continuous variables to find correlations, respectively. It should be noted that the marginal significance level for the tests (p-value) was considered 0.05.

## 3- RESULTS

**Table 1** shows demographics, length of hospital stay, field of surgery, and screening methods in each group. A total of 1028 children were included in the study with an average age of  $60.51 \pm 50.3$  months. Elective surgeries were slightly more frequent than emergency surgeries. Moreover, most operations were performed in pediatric surgery, dentistry, and neurosurgery, respectively. Furthermore, appendectomy (laparoscopic or open), dental procedures, hernia/undescended testis, urologic disorders, and percutaneous catheters (other than central venous catheters) were the most frequent procedures during this period, respectively (**Fig. 1**). In addition, the ratio of emergency to elective surgeries (EE ratio) was 0.86.

The average age of patients in the emergency group was significantly higher than that in the elective group (69.1 vs. 53.0 months,  $p < 0.001$ ). There was a male dominance in operated patients in total, and in each group (67.9% vs. 32.1%,  $p < 0.001$ ). Moreover, the mean length of hospital stay was much higher in patients who underwent emergency surgeries (**Table 1**).

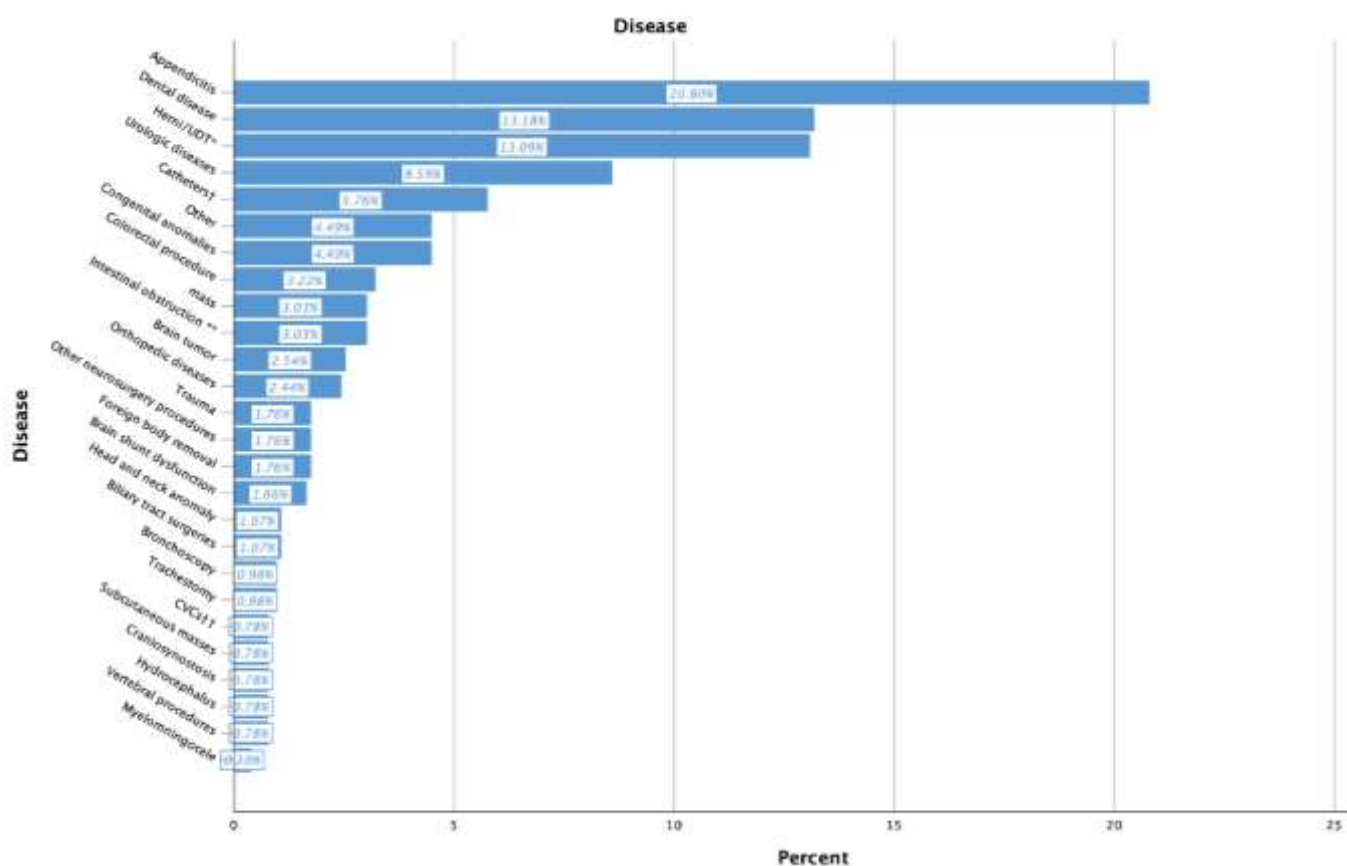
### 3-1. Morbidity and mortality

In this study, 87 patients (8.5%) developed various degrees of morbidity (regardless of the COVID-19 result). These conditions included pulmonary infection, convulsion, intestinal obstruction, wound infection, gastrointestinal bleeding, fistula formation, sepsis, peritonitis, pneumothorax, or anastomotic leaks. **Table 2** concisely shows the distribution of morbidity in other variables. It should be noted that pulmonary infection includes a wide range

of infectious lung disorders, such as bacterial pneumonia, empyema, and other lower respiratory infections.

At a glance, it should be drawn that the rate of morbidity development was higher in emergencies and in those with a positive COVID-19 test. On the other hand, 80% of positive cases in elective operations, and 34% in emergency surgeries have developed at least one case of morbidity (p

< 0.001). **Fig. 2** illustrates the distribution of morbidities in both positive and negative cases of COVID-19. Despite the higher rate of wound infection (20.7%) in non-COVID children, pulmonary infection (6.9%) had the most common morbidity rate among the COVID-positive patients (p = 0.421) (**Fig. 3**).



**Fig. 1:** the distribution of surgeries performed during the pandemic in a bar chart.

\* UDT: Undescended testis. † Catheters other than central venous catheters including percutaneous pig-tale catheters for abscess drainages, nephrostomies, etc. \*\* The most common intestinal obstruction was intussusception. †† CVC = central venous catheters.

(Other included Pulmonary abscess, Portal hypertension, Splenectomy, Peritonitis, Pericardiocentesis, Circumcision, GI reflux, Subcutaneous abscess, Gastrostomy (surgical), Cholecystectomy, Biopsies, Thoracotomy/VATS, Upper GI endoscopic interventions, / (Percutaneous liver biopsy, Esophageal stricture, and Lumbar puncture

**Table-1:** Demographics and primary information of included cases

Variable	Total Value	Elective	Emergency	p-value*
Cases (%)	1028	550 (53.7)	475 (46.3) †	-

Age (mean)		60.51 ± 50.3 months	53.05 ± 45.1	69.18 ± 54.6	< 0.001
Gender (%)	Male	692 (67.9)	395 (71.9)	297 (63.2)	0.003
	Female	327 (32.1)	154 (28.1)	173 (36.8)	
Length of stay (mean)		6.32 ± 11.9 days	4.09 ± 8.0	8.92 ± 14.9	< 0.001
Field of surgery	Pediatric surgery	685 (66.8)	336 (49.1)	349 (50.9)	-
	Dentistry	135 (13.2)	133 (98.5)	2 (1.5)	
	Neurosurgery	103 (10.0)	49 (47.6)	54 (52.4)	
	Orthopedics	35 (3.4)	17 (48.6)	18 (51.4)	
	Anesthesiology	34 (3.3)	4 (11.8)	30 (88.2)	
	Pulmonology	19 (1.9)	2 (10.5)	17 (89.5)	
	Gastroenterology	9 (0.9)	6 (66.7)	3 (33.3)	
	ENT	5 (0.5)	3 (60)	2 (40)	
Screening method	PCR	601 (59.7)	464 (77.2)	137 (22.8)	< 0.001
	Lung CT and PCR	24 (2.4)	5 (20.8)	19 (79.2)	
	CBC and Chest x-ray	167 (16.6)	31 (18.6)	136 (81.4)	
	Lung CT	181 (18.0)	22 (12.2)	159 (87.8)	
	None	34 (3.4)	16 (47.1)	18 (52.9)	

\*Pearson Chi-square test was implemented for gender, field of surgery, and screening methods. Also, a one-way ANOVA test was used for age and length of stay.

†Emergency to elective surgery ratio (EE ratio) is 0.86.

**Table-2:** Morbidity and mortality rates in respect of the priority of operations

Priority	COVID negative				COVID positive			
	Morbidity*	Total	Mortality	Total	Morbidity	Total	Mortality	Total
Elective	15 (2.8)	537	5 (1.1)	459	8 (80)	10	1 (14.3)	7
Emergency	56 (12.4)	451	11 (2.9)	378	8 (34)	23	5 (25)	20
P-value	< 0.001		0.002		< 0.001		0.002	

\*morbidity stands for any abnormal postoperative condition which leads to prolonged length of hospital stay due to infections, need for another surgery, extra doses of antibiotics etc. Detailed list of morbidities is depicted in Fig. 2.

Also, 22 patients (2.5%) had died during their admission (1.3% elective vs. 4% emergency). The rate of expired cases was higher in patients who were positive for COVID-19 (22.2% vs. 1.9%,  $p < 0.001$ ). Furthermore, 25.3% of mortalities occurred in those who had developed some degrees of morbidity ( $p < 0.001$ ). Also, pulmonary infection was the most related condition to mortality ( $p < 0.001$ ).

It should be noted that among positive patients for COVID-19, there was no significant association between mortality with age ( $p = 0.415$ ), gender ( $p = 0.601$ ), and length of stay ( $p = 0.06$ ). This is true for the association between morbidity and other variables. However, the length of stay was significantly higher in COVID-positive and morbid patients than in other patients ( $p = 0.03$ ).

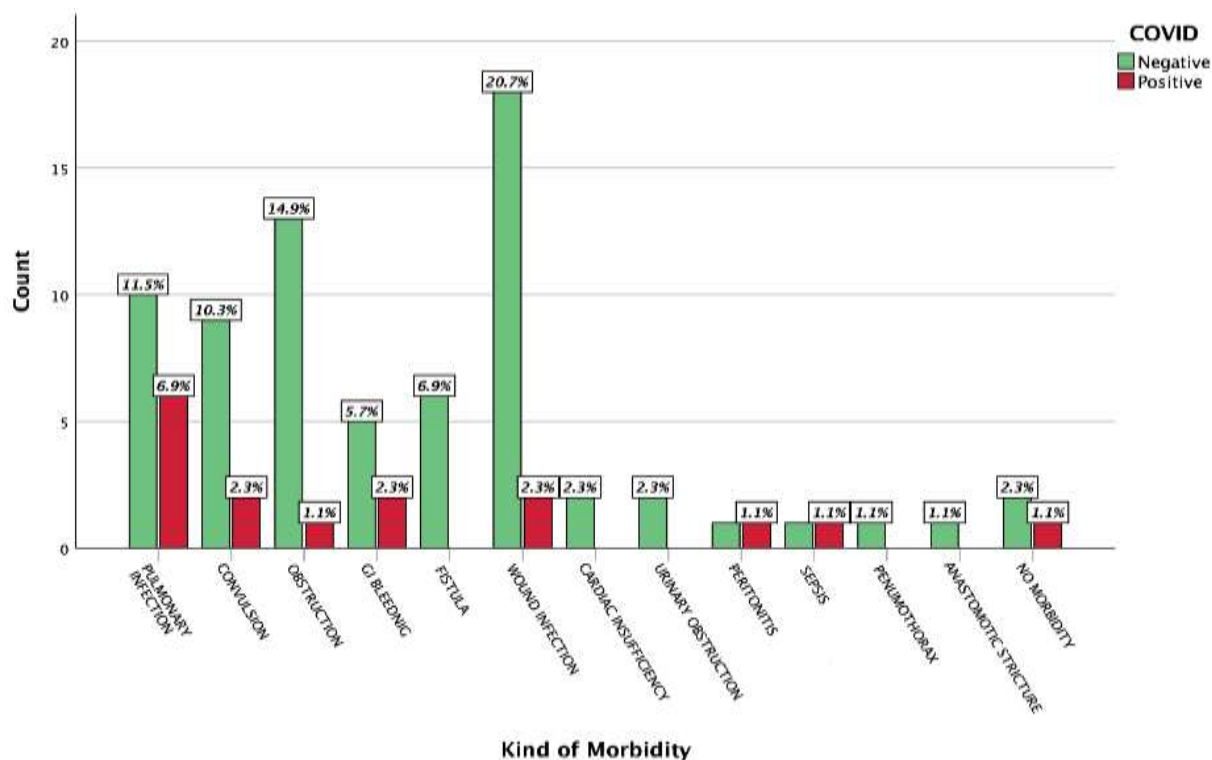


Fig. 2: the frequency of COVID-positive and negative children in each surgical subspecialty.

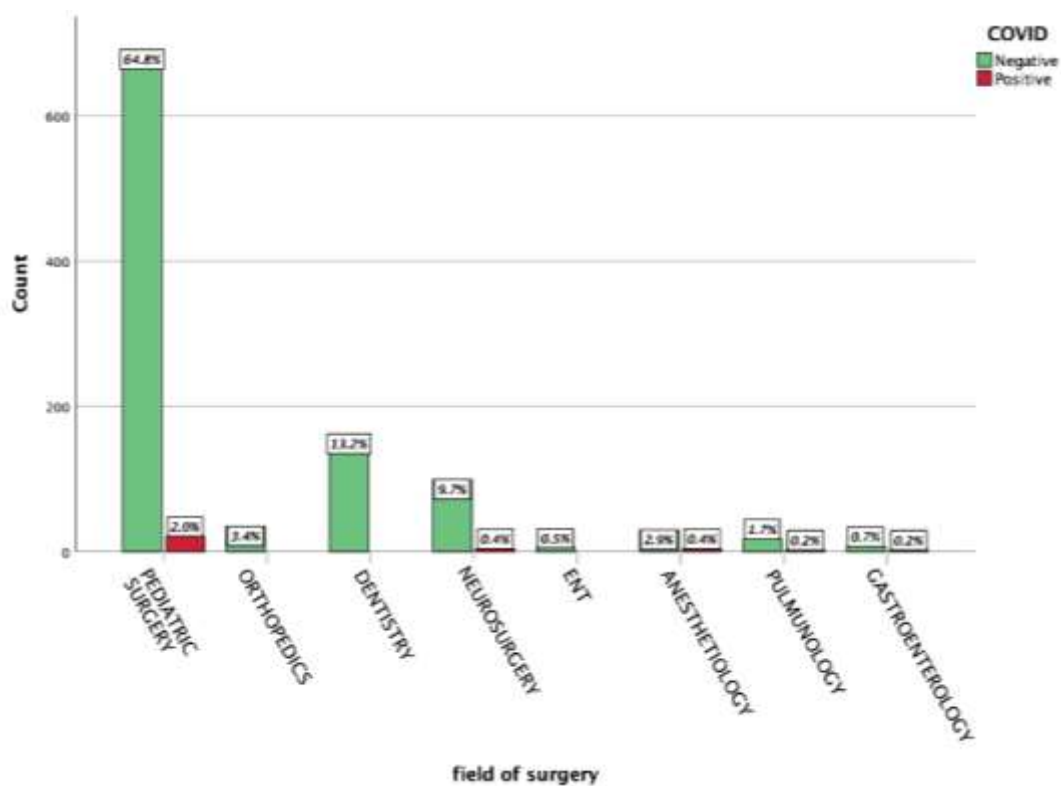


Fig. 3: the frequency of various morbidities regarding COVID-19 infection.

#### 4- DISCUSSION

The obtained findings revealed a higher rate of morbidity in patients who underwent emergency operations. Additionally, the rates of complications, and mortalities were significantly higher in patients with a positive COVID-19, regardless of the priority of surgery. Moreover, the EE ratio was 0.86 which is a raw number by itself. In fact, EE ratio can be used as a reliable surgical access metric in unexpected situations (14-16). However, there was no access to the previous EE ratios of our center. Therefore, it is possible to compare this number with the existing literature.

Regardless of the pandemic, the EE ratio was measured in different countries, and had a wide range of 1.6-557.4 (16). In the setting of the pandemic, this ratio has changed reasonably. Although we could not find any systematic review generating an overall precise EE ratio, it can be extracted from the literature. For example, the EE ratio was increased from 1.27 to 3.78 in a multicenter study of orthopedic surgeries during the COVID-19 outspread, suggesting a significant increase in emergency operations or decreased number of elective surgeries (17). Also, in a retrospective report of five children's hospitals in Africa on 1821 patients, the EE ratio was increased from 0.3 to 1.4 (18). Another study in a children's surgical institute, estimated this rate to be within the range of 0.37-0.34 in a six-month period (19). Considering that children-specific healthcare centers are usually referral hospitals, their rate of emergency surgeries is less than that of general hospitals. For this reason, higher EE ratios are not expected in children-dedicated hospitals. Although there was no access to previously published reports of the investigated center's EE ratios, the rate of elective surgeries decreased from 8000 to 1000 in one year. However, in the present study, the EE ratio was 0.86, which

indicates the decreased number of elective operations.

As previously mentioned, there were more complications in patients who underwent emergency operations. Another important finding was the higher rates of morbidity and mortality in emergency operations during the pandemic. Furthermore, the overall rate of mortality was 2.5%. Logically, in the normal population, the morbidity and mortality are much higher in patients who underwent emergency operations compared to elective surgeries (13.8% vs. 6.7% morbidity, and 3.7% vs. 0.4% mortality) (20).

At present, the above-mentioned hypothesis should be tested during the COVID-19 outbreak. Therefore, due to the reduced number of elective operations and delayed time of visiting hospitals for emergency disorders, higher rates of complications and mortality in emergency procedures were expected during the pandemic. For example, in a retrospective study similar to the current study, complications and mortalities were much higher in the emergency group (25% vs. 8.8%, and 10.3% vs. 4.4%) (21). Another study with 9925 patients, reported the higher rates of complications and mortalities in an emergency setting and in those with a positive COVID-19. The overall mortality rates, in total, in elective and emergency procedures were reported as 1.7%, 0.7%, and 3.6%, respectively (22).

Among emergent or urgent surgical procedures, acute appendicitis is the most frequent operation in the children population (23, 24). As in the current study, 44.5% of emergency operations were dedicated to appendectomy surgery. The appendicitis is well reported, as one of the leading causes of surgical emergencies in children, with acceptable outcomes (25).

The impact of COVID-19 infection on mortality rate of surgeries has been

revealed in several investigations. However, these investigations were not done specifically in the pediatric population. For instance, the mortality rate in COVID-19 positive patients who underwent hip surgeries was up to 3.65 times more than the expected (26). A meta-analysis of 39 articles suggests that the mortality rate can be 7-fold higher in positive cases (27). The present study reveals a 13-fold higher rate in elective, and an 8.6-fold higher rate in emergency surgeries.

#### 4-1. Limitations of the study

Although the present findings are based on a relatively large sample, there are some potential limitations. The study was conducted retrospectively, without matching or randomization which may affect the reliability of data. However, prospective randomized studies in this context could be difficult to conduct. Moreover, there are some potential confounding factors that affect both elective and emergency surgeries. These factors can be reduced in cohort comparative studies.

#### 5- CONCLUSION

The present study's findings revealed some differences in the ratio of emergency to elective procedures. Emergency surgical interventions can be associated with higher rates of complications and mortalities. Moreover, COVID-19 infection can increase the risk of postoperative morbidity and mortality in children in both elective and emergency settings.

#### 6- CONFLICT OF INTEREST

None.

#### REFERENCES

1. Zhu, N., Zhang D, Wang W, Li X, Yang B, Song J, Zhao X, Huang B, Shi W, Lu R, Niu P, Zhan F, Ma X, Wang D, Xu W, Wu G, Gao GF, Tan W, China Novel Coronavirus Investigating and Research

Team., A Novel Coronavirus from Patients with Pneumonia in China, 2019. *New England Journal of Medicine*, 2020. 382(8): p. 727-733.

2. Salimi, R., R. Gomar, and B. Heshmati, The COVID-19 outbreak in Iran. *J Glob Health*, 2020. 10(1): p. 010365.

3. Ng, K.H. and R. Kemp, Understanding and reducing the fear of COVID-19. *J Zhejiang Univ Sci B*, 2020. 21(9): p. 752-754.

4. Iacobucci, G., Covid-19: all non-urgent elective surgery is suspended for at least three months in England. *BMJ: British Medical Journal (Online)*, 2020. 368.

5. Dedeilia, A., Sotiropoulos MG, Hanrahan JG, Janga D, Dedeilias P, Sideris M. Medical and surgical education challenges and innovations in the COVID-19 era: a systematic review. *In vivo*, 2020. 34(3 suppl): p. 1603-1611.

6. Abolghasemian, M., Ebrahimzadeh MH, Enayatollahi M, Honarmand K, Kachooei AR, Mehdipoor S, Mortazavi MJ, Mousavian A, Parsa A, Akasheh G, Bagheri F, Ebrahimpour A, Fakoor M, Moradi R, Razi M. Iranian orthopedic association (IOA) response guidance to COVID-19 pandemic april 2020. *Archives of Bone and Joint Surgery*, 2020. 8(Suppl 1): p. 209.

7. Tavanaei, R., Ahmadi P, Yazdani KO, Zali A, Oraee-Yazdani S. The impact of the coronavirus disease 2019 pandemic on neurosurgical practice and feasibility of safe resumption of elective procedures during this era in a large referral center in Tehran, Iran: an unmatched case-control study. *World Neurosurgery*, 2021. 154: p. e370-e381.

8. Wang, X., Gao H, Zhang Z, Deng C, Yan Y, Shi 4. Effect of the COVID-19 pandemic on complications and mortality of patients with cardiac surgery. *J Cardiothorac Surg*, 2021. 16(1): p. 361.



9. Prasad, N.K., Lake R, Englum BR, Turner DJ, Siddiqui T, Mayorga-Carlin M, Sorkin JD, Lal BK. Increased complications in patients who test COVID-19 positive after elective surgery and implications for pre and postoperative screening. *The American Journal of Surgery*, 2022. 223(2): p. 380-387.
10. Doglietto, F., Vezzoli M, Gheza F, Lussardi GL, Domenicucci M, Vecchiarelli L, Zanin L, Saraceno G, Signorini L, Panciani PP, Castelli F, Maroldi R, Rasulo FA, Benvenuti MR, Portolani N, Bonardelli S, Milano G, Casiraghi A, Calza S, Fontanella MM. Factors associated with surgical mortality and complications among patients with and without coronavirus disease 2019 (COVID-19) in Italy. *JAMA surgery*, 2020. 155(8): p. 691-702.
11. Madrazo, Z., Osorio J, Otero A, Biondo S, Videla S; on behalf of The COVID-CIR Collaborative Group. Postoperative complications and mortality following emergency digestive surgery during the COVID-19 pandemic: A multicenter collaborative retrospective cohort study protocol (COVID-CIR). *Medicine*, 2021. 100(5).
12. Unterfrauner, I., Hruby LA, Jans P, Steinwender L, Farshad M, Uçkay I. Impact of a total lockdown for pandemic SARS-CoV-2 (Covid-19) on deep surgical site infections and other complications after orthopedic surgery: a retrospective analysis. *Antimicrobial Resistance & Infection Control*, 2021. 10(1): p. 1-9.
13. Hatami, H., Abbasi-Kangevari M, Malekpour MR, Kolahi AA. Knowledge, Attitudes, and Safety Practices about COVID-19 among High School Students in Iran during the First Wave of the Pandemic. *Front Public Health*, 2021. 9: p. 680514.
14. de Jager, E., R. Gunnarsson, and Y.-H. Ho, Emergency to Elective Surgery Ratio as a Disparities Sensitive Surgical Access Metric, a Study of Low Socioeconomic Status in Australia. *World Journal of Surgery*, 2022. 46(4): p. 776-783.
15. Schöni, D., M.-E. Halatsch, and A. Alfieri, The impact of reduced operating room capacity on the time delay of urgent surgical care for neurosurgical patients during the COVID-19 pandemic. *Interdisciplinary Neurosurgery*, 2022. 29: p. 101544.
16. Prin, M., Guglielminotti J, Mtalimanja O, Li G, Charles A. Emergency-to-Elective Surgery Ratio: A Global Indicator of Access to Surgical Care. *World Journal of Surgery*, 2018. 42(7): p. 1971-1980.
17. Wong, J.S.H. and K.M.C. Cheung, Impact of COVID-19 on Orthopaedic and Trauma Service: An Epidemiological Study. *J Bone Joint Surg Am*, 2020. 102(14): p. e80.
18. Mazingi, D., Shinondo P, Ihediwa G, Ford K, Ademuyiwa A, Lakhoo K. The impact of the COVID-19 pandemic on pediatric surgical volumes in Africa: A retrospective observational study. *Journal of Pediatric Surgery*, 2022.
19. Seck NF, Zeng FTa, Sy F, Ba MF, Ndoeye NA, Wellé IB, Alassane MP, Gueye D, Sagna A, Ngom G. Impact of the covid-19 pandemic on pediatric surgical practice: the experience of a Senegalese tertiary children's hospital.
20. Mullen, M.G., Michaels AD, Mehaffey JH, Guidry CA, Turrentine FE, Hedrick TL, Friel CM. Risk Associated With Complications and Mortality After Urgent Surgery vs Elective and Emergency Surgery: Implications for Defining "Quality" and Reporting Outcomes for Urgent Surgery. *JAMA Surgery*, 2017. 152(8): p. 768-774.
21. De Luca, M., Sartori A, Vitiello A, Piatto G, Noaro G, Olmi S, Foschi D, Re LD, Zappa M, Sarro G, Rivolta U, Giraudo G, Borghi F, Pozzo G, Sorisio V, Pignata G, Greco PA, Sisti V, Campagnaro T,

- Guglielmi A, Andreuccetti J, Leo AD, Lauro E, Ricci F, Musella M, Zizzo M, Bonacini S, Podda M, Pisanu A, Coletta P, Guerrieri M, Caracino V, Basti M, Pilone V, Raffaelli M, Oragano L. Complications and mortality in a cohort of patients undergoing emergency and elective surgery with perioperative SARS-CoV-2 infection: an Italian multicenter study. Teachings of Phase 1 to be brought in Phase 2 pandemic. *Updates in Surgery*, 2021. 73(2): p. 745-752.
22. Minto, T., Abdelrahman T, Jones L, Wheat J, Key T, Shivakumar N, Ansell J, Seddon O, Cronin A, Tomkinson A, Theron A, Trickett RW, Sagua N, Sultana S, Clark A, McKay E, Johnson A, Behera K, Towler J, Kynaston H; Cardiff and Vale COVID-19 Research Collaborative. Safety of maintaining elective and emergency surgery during the COVID-19 pandemic with the introduction of a Protected Elective Surgical Unit (PESU): A cross-specialty evaluation of 30-day outcomes in 9,925 patients undergoing surgery in a University Health Board. *Surgery Open Science*, 2022. 10: p. 168-173.
23. 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. *International Journal of Surgery*, 2021. 95: p. 106148.
24. Sømme, S., Bronsert M, Morrato E, Ziegler M. Frequency and Variety of Inpatient Pediatric Surgical Procedures in the United States. *Pediatrics*, 2013. 132(6): p. e1466-e1472.
25. Mohajerzadeh, L., Ebrahimian M, Sarafi M, Ebrahimisaraj G, Tabatabaei SR, Noorbakhsh SM, Kaveh A, Taheri H, Azimi L, Alebouyeh M. Effects of COVID-19 Pandemic on the Frequency of Complicated Appendicitis in Pediatric Populations. *Arch Pediatr Infect Dis*, 2023. 11(1): p. e129026.
26. Freitas, T., Ibrahim A, Lourenço A, Chen-Xu J. Mortality in COVID-19 patients after proximal femur fracture surgery: a systematic review and meta-analysis. *Hip Int*, 2022: p. 11207000221116764.
27. Brown, W.A., E.M. Moore, and D.A. Watters, Mortality of patients with COVID-19 who undergo an elective or emergency surgical procedure: a systematic review and meta-analysis. *ANZ J Surg*, 2021. 91(1-2): p. 33-41.