

The COVID-19 pandemic first wave in Sweden: A national registry study of the effects on pediatric anesthesia and surgery

Sixten Melander | Jimmy Almström | Gunnar Enlund  | Peter Frykholm  

Department of Surgical Sciences, Section of Anaesthesia and Intensive Care Medicine, Uppsala University, Uppsala, Sweden

Correspondence

Peter Frykholm, Department of Anaesthesia and Intensive Care, Uppsala University Hospital, 751 85 Uppsala, Sweden.

Email: Peter.Frykholm@surgsci.uu.se

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Abstract

Background: The COVID-19 pandemic is pushing healthcare systems to their limits. Dramatic reductions in the adult elective surgery are ubiquitous, but corresponding changes in pediatric services are not well described. The Swedish Perioperative Registry contains data on all anesthetic procedures in Sweden, and therefore, provides a unique opportunity to analyze the effect of the pandemic on the pediatric anesthesia capacity on a national level. We hypothesized that there would be a significant reduction in pediatric elective procedures. The aim was to determine the effects on pediatric surgical and anesthetic services during the first wave of the COVID-19 pandemic in Sweden.

Methods: For this retrospective registry cohort study, we extracted all procedures performed on patients <18 years of age in 2020 and 2019. Weeks 12 to 26 of 2020 were defined as the first wave, and data were analyzed according to level of care, type of surgery, procedure code, and emergency or elective surgery.

Results: We found 7015 fewer procedures during the first wave epoch. Elective cases were reduced by 53.7% while emergency surgery was not significantly affected. During the peak of the first wave in April, there was a 72.8% reduction in elective cases; ENT/maxillofacial surgery showed the greatest reduction (86.7%). The surgical and anesthesia capacity recovered to near-normal levels by the end of June 2020.

Conclusion: We conclude that the impact of COVID-19 on pediatric surgical procedures in Sweden during the first wave of the pandemic was dramatic, but elective services were restored a few months after the peak.

KEYWORDS

COVID-19, general surgery, orthopedic surgery, pediatric hospitals, workload

1 | INTRODUCTION

The COVID-19 pandemic has changed national healthcare systems dramatically with an increasing need to prioritize patients with urgent medical conditions. It is estimated that elective surgeries globally have been reduced by as much as 80% during the worst months of the virus outbreak.¹ Compared with most other

countries, Sweden has adopted a different approach during the pandemic trying to flatten the curve using recommendations instead of lockdowns.² Despite this strategy, a recently published report by the Swedish National Board of Health and Welfare confirmed similar reductions in elective surgery within the adult population as seen in most other countries. There is now growing

concern that this backlog of surgical procedures will lead to an increase in patient morbidity and mortality.³

Children are generally considered less likely to develop severe COVID-19 disease and represent a low proportion of diagnosed cases.⁴ Regardless, one can suspect that many pediatric hospitals have been forced to change their focus to emergency care because of uncertainty regarding total number of hospital beds and the relocation of personnel. Another consideration is the cancelation of elective procedures due to the fact that children are prone to common colds, which are difficult to differentiate from COVID-19 symptoms. The extent to which elective surgery within the pediatric population has been affected during this past year is uncertain, but an international survey has indicated similar reductions as within the adult population.⁵ In order to mitigate the negative effects of postponed procedures and finding ways to restart national healthcare systems, we need to present robust data and analysis on a national level.

The Swedish Perioperative Registry (SPOR) contains data on virtually all performed surgeries in Sweden.⁶ An important purpose of the registry is to enable regional and national comparisons, and therefore, enhance the quality of anesthesia and surgical care in the Swedish healthcare system. In the context of our study, SPOR provides a unique opportunity to present actual outcomes in regard to pediatric anesthesia and surgery on a nationwide scale. The aim of this article was to present how pediatric surgery and procedures requiring anesthesia in Sweden have been affected during the first wave of the pandemic. Our hypothesis was that there would be a significant reduction in elective procedures during the first wave of the pandemic compared with the number of procedures during the corresponding period the previous year.

2 | METHODS

After ethics approval (Swedish Ethical Review Authority 2020-01909), a report of all registered procedures in subjects <18 years of age during 2019 and 2020 was requested from SPOR. Written informed consent was waived. The STROBE checklist for observational studies was adhered to. After approval from the SPOR scientific committee, the report was acquired in October 2020. The report contained no personal identification numbers, but a wide range of data on every procedure such as age of the patient, date and time of procedure, diagnosis, anesthesia code, surgical code, and elective/emergency status. Centers that joined SPOR later than January 2019 were excluded.

The primary endpoint was reduction in surgical procedures, diagnostic procedures, or other treatments requiring anesthesia. Secondary endpoints were differences between hospital type and main specialties, respectively. We started by analyzing weekly changes in the total number of procedures, comparing two corresponding epochs: week 3 to week 34 in 2020 and 2019, respectively. This interval was chosen to include a few weeks before the first Swedish COVID-19 cases were diagnosed, encompassing the whole first wave of the pandemic but also the aftermath during

What is already known about this subject

In many countries, the COVID-19 pandemic has had a profound and long-lasting impact on healthcare systems in general and elective surgery in particular.

What this article adds

Using a new national database for anesthesia and surgery, we provide data on the reduction in the number of pediatric procedures requiring anesthesia during the first wave of the pandemic in the spring of 2020 in Sweden. Elective ENT surgery was most severely affected; all services returned to normal in less than four months.

summer. The next step was to define the period for quantitative analysis. For the purposes of this study, we defined the first wave of the pandemic as the period including the first and last consecutive weeks with more than 5% decrease in number of procedures. We analyzed the weekly data categorized according to level of care (university hospital, county hospital, and district hospital), type of surgery (limited to general surgery, orthopedic surgery, urologic surgery, and ENT/maxillofacial surgery), procedure code (limited to the 10 most common procedures), and emergency or elective surgery. Finally, we identified the peak of the first wave as the single week with the most prominent reduction in total number of procedures.

We extracted data on total (adult and pediatric) COVID-19 infection rate and death rate from the Swedish Public Health Agency (www.folkhalsomyndigheten.se) and number of COVID-19 patients in intensive care from the Swedish ICU Registry (www.icuregsw.org).^{7,8}

2.1 | Statistical methods

No power analysis was performed since the measurement period was defined *a priori*. The mean and number of weekly procedures were reported, and the differences between the epochs were displayed as 95% confidence intervals (95% CI) and percentage changes. Repeated measures ANOVA or Student's t test (two-sided, paired samples) were used to detect weekly changes and differences between the two epochs. $p < .05$ signified statistical significance.

3 | RESULTS

In total, 68 Swedish hospitals reported 10 991 pediatric surgical or diagnostic procedures in the selected period of 2020 compared to 18 006 in the matched weeks of 2019. This amounts to 7015 fewer procedures during the pandemic and, therefore, a reduction in the total number of 39.0%. The reduction in elective cases was 53.7% (6819 fewer cases, $p < .001$).

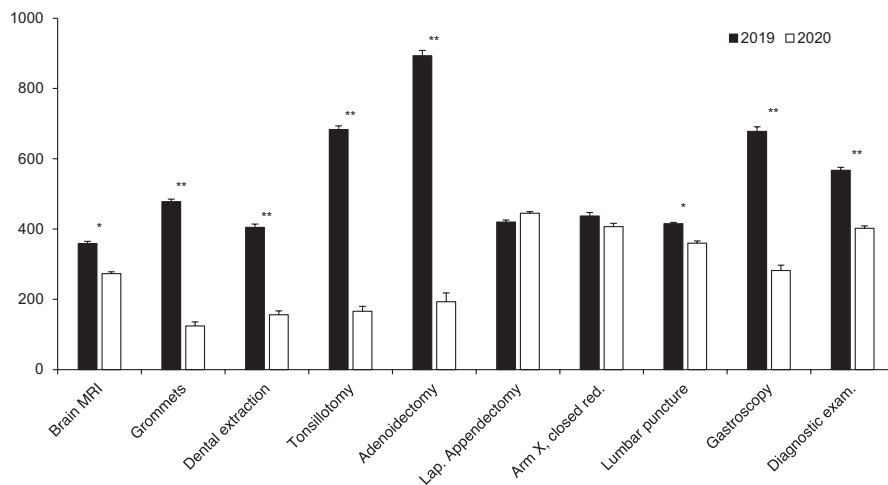


FIGURE 1 Number of performed anesthetics for the ten most common procedures in 2019 (y-axis), comparing 2020 and 2019 during the first wave of the pandemic, in this paper encompassing 14 weeks from March 15 to June 27. Arm X—arm fracture. Diagnostic examination includes some nonoperating room procedures. * $p < .05$, ** $p < .001$

TABLE 1 Number of procedures performed in the 2019 and 2020 epochs in the four main surgical specialties, mean differences (%) and 95% CI of the differences between the means, and absolute (%) changes in the second week of April (Peak Week)

Specialty		2019	2020	Difference	95% CI	Peak Week
General	Emergency	929	903	-26 (-2.80%)	(-8.30 - 4.83)	-23 (-28.0%)
	Elective	652	331	-321 (49.2%)	(-28.8 - -14.1)	-46 (-85.2%)
Orthopedic	Emergency	2153	2147	6 (0.279%)	(-16.3 - 15.5)	-1 (-0.94%)
	Elective	1684	876	-808 (-48.0%)	(-68.5 - -39.2)	-85 (70.8%)
Urological	Emergency	238	225	-13 (-5.46%)	(-74.91 - 3.18)	-6 (-35.3%)
	Elective	938	366	-572 (-61.0%)	(-41.9 - -34.4)	-64 (77.1%)
ENT/Maxillofacial	Emergency	250	191	-59 (-23.6%)	(-359 - -338)	-8 (-36.4%)
	Elective	4100	1138	-2962 (-72.2%)	(-95.1 - -72.0)	-267 (-86.7%)
Total	Emergency	5298	5102	-196 (-3.70%)	(-28.7 - 2.55)	-45 (-12.9%)
	Elective	12 708	5889	-6819 (-53.7%)	(-552 - -357)	-705 (-72.8%)

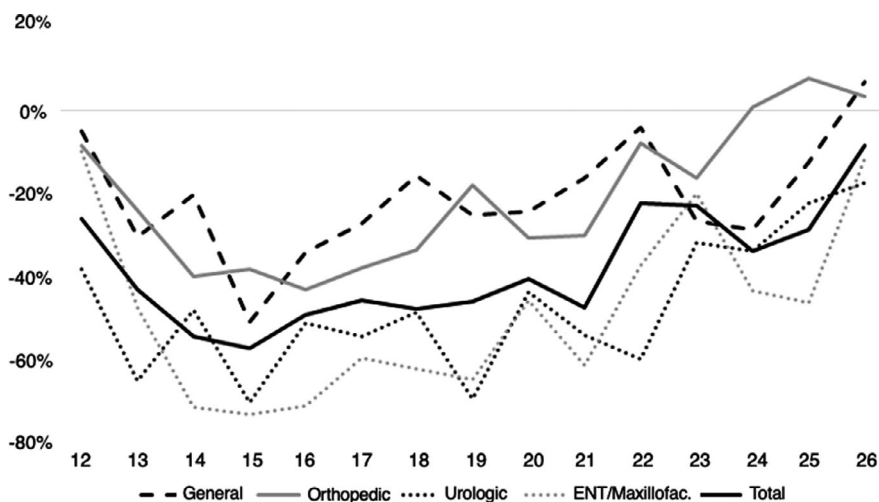


FIGURE 2 Percentage reductions in caseload during the first wave of the pandemic (y-axis), in this paper encompassing 14 weeks from March 16 to June 28 (week 12, starting March 16th—week 26, starting June 22, ISO standard week numbers on the x-axis). General surgery and orthopedic surgery were less severely affected than ENT/maxillofacial surgery and urologic surgery

The peak of the first wave was week 15 (second week of April) during which a 57.0% reduction in total caseload was registered (750 less cases in 2020); the reduction in elective cases was 72.8%. The 10 most common procedures in 2019 and the corresponding numbers in 2020 are shown in Figure 1.

The effects on elective and emergency surgery in the four major surgical specialties are displayed in Table 1 and Figure 2. During the peak week, elective surgery was severely affected in all four specialties, ranging from 68.3% in orthopedics to 86.7% in ENT/maxillofacial surgery, which also showed the greatest effects on total

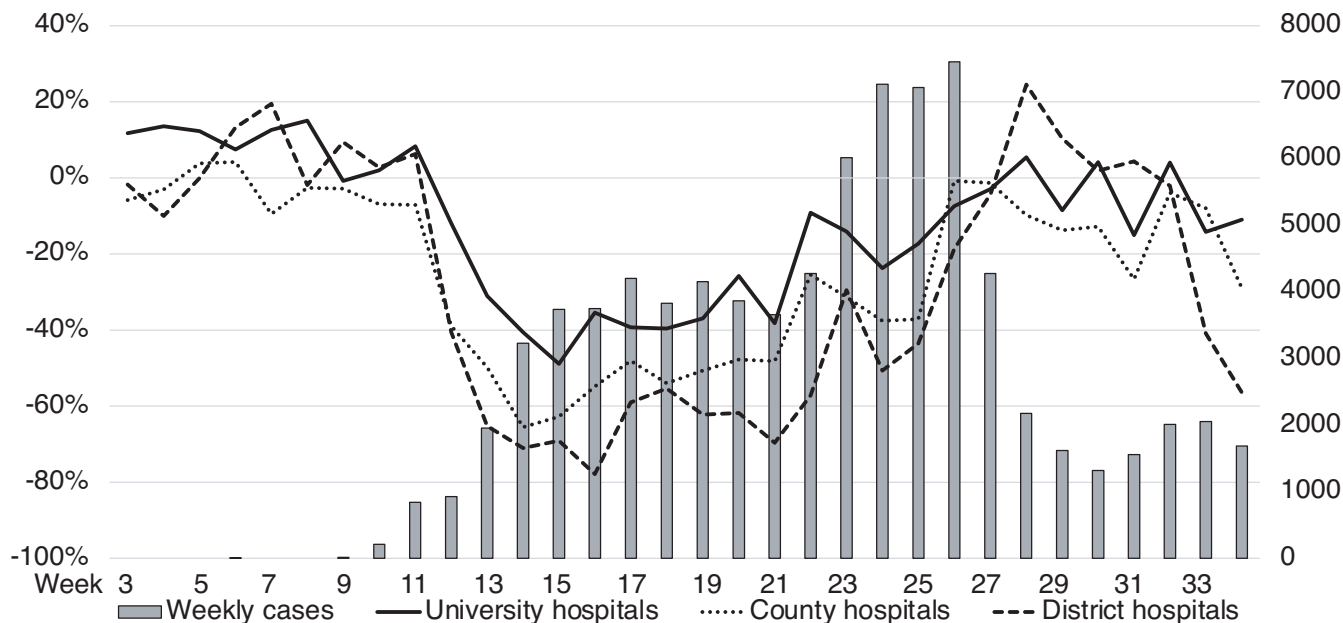


FIGURE 3 Percentage reduction in caseload during the spring and summer weeks of 2020 in university hospitals, county hospitals, and district hospitals (left y-axis). This graph includes several weeks before and after the epoch that was analyzed as the “first wave” in this paper, illustrating how the latter started in week 12 (the third week of March, starting March 16), peaked in week 15 (the second week of April, starting April 6) and ended after week 26 (ISO standard week numbers on the x-axis). The bars represent the weekly total number of positive COVID-19 tests in Sweden (right y-axis), data from the Public Health Agency⁷

TABLE 2 Number of procedures in the 2019 and 2020 epochs in three levels of hospitals in the 2019 and 2020 epochs, mean differences (%) and 95% CI of the differences between the means, and absolute (%) changes in the second week of April (Peak Week)

Level of Care		2019	2020	Difference	95% CI	Peak Week
University Hospital	Emergency	2777	2633	144 (-5.19%)	(-18.3 - -0.834)	-26 (13.9%)
	Elective	6156	3752	2404 (-39.1%)	(-206 - -115)	-302 (62.4%)
County Hospital	Emergency	1948	1932	-16 (-0.82%)	(-12.3 - 10.1)	-19 (-15.1%)
	Elective	4452	1583	-2869 (-64.4%)	(-230 - -153)	-266 (-80.9%)
District Hospital	Emergency	573	537	36 (6.28%)	(-6.64 - 1.84)	1 (2.94%)
	Elective	1917	530	1387 (-72.4%)	(-112 - -72.5)	-122 (-86.5%)

surgical volumes (83.3% reduction). For the whole period, emergency surgery was only marginally affected—the 23.6% reduction in ENT/maxillofacial emergency surgery was compensated by a slight increase in the other specialties.

When comparing different types of hospitals, we found that university hospitals (n = 13) reduced their elective capacity by 39.1%, county hospitals (n = 18) by 64.4%, and district hospitals (n = 36) by 72.4% (Figure 3, Table 2). Compared with university hospitals, the relative reductions were significantly greater in the district hospital and county hospital groups than in the university hospital group (p < .001 for both comparisons). Likewise, total caseload reductions were significantly different between university hospitals and district hospitals (p < .001) and county hospitals (p < .05), respectively.

For reference, the weekly total number of COVID-19 positive tests is superimposed on the changes in hospital case load in

Figure 3. In addition, the total death rate due to COVID-19 and ICU admissions (including both adults and children) is displayed in Figure 4, while Table 3 contains selected events and issued recommendations during the studied period.

4 | DISCUSSION

We performed a registry-based analysis of the impact of COVID-19 on procedures involving anesthesia in children in Sweden. We could demonstrate severe but transient reductions in the total number of weekly procedures during the first wave of the pandemic. Our data show a maximum reduction by 57% during the peak in April, but a more modest average reduction of 39% for the whole study period. The changes were almost entirely affected due to cancelations of elective procedures (54%), while emergency

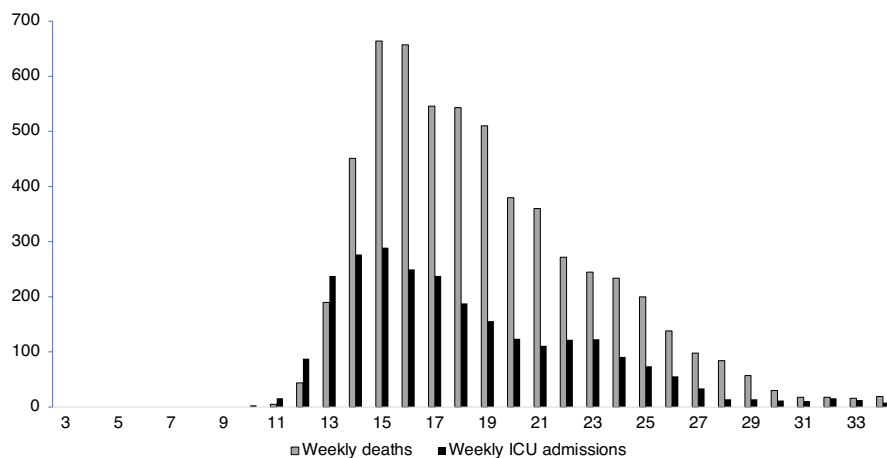


FIGURE 4 Weekly death rate in COVID-19 in Sweden and weekly total number of COVID-19 patients in intensive care on the y-axis (including adult and pediatric patients), the x-axis shows the ISO standard week number. Week 15, starting April 6 was the peak week. Data from the Public Health Agency and the Swedish Intensive Care Registry^{7,8} [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Selected events and government actions in Sweden during the first wave of the pandemic. The National Board of Health and Welfare (SoS) and the Public Health Agency are both government agencies under the Ministry of Health and Social Affairs

Date	Event
31-Jan	First case of COVID-19 in Sweden.
3-Mar	Healthcare providers encouraged to increase testing but testing capacity very limited.
10-Mar	The Public Health Agency issues advice to the public: avoid unnecessary visits to health care and elderly care.
11-Mar	Gatherings of more than 500 people should be canceled. WHO declares COVID-19 a pandemic.
14-Mar	The Ministry for Foreign Affairs advises against international travel until July 15.
17-Mar	COVID-19 diagnostics available at all university hospitals in Sweden but the capacity is limited. High schools, colleges and universities to initiate distance learning, but primary and secondary schools unchanged.
19-Mar	The Public Health Agency advises the public to avoid unnecessary travel
20-Mar	Government asks the SoS to coordinate the need for ICU beds.
21-Mar	Swedish military deploys first field hospital.
27-Mar	Public gatherings of more than 50 people forbidden.
30-Mar	Public Health Agency recommendations: All visits to nursing homes are forbidden. Mission to increase testing. Advice on physical distancing and personal responsibility.
29-Apr	Shortage of certain intensive care medications in some hospitals. Swedish ICU capacity doubled
4-Jun	Government orders the SoS to coordinate health care needs for the summer.
13-Jun	Travel restrictions within Sweden eased.
15-Jun	COVID-19 self-testing available in Stockholm and later in the rest of Sweden.
31-Aug	Recommendations for COVID-19 testing of symptomatic school children. (Testing in children previously almost only for hospitalized children)

surgery was left largely unaffected. In general, the reduction in procedures was more prominent in smaller hospitals. This is probably related to the fact that more complex pediatric cases are centralized to the university hospitals and, therefore, less likely to be canceled, while county and district hospitals deal mainly with basic ENT surgery and the occasional pediatric trauma and other emergencies. As the infection rate abated at the beginning of summer, many hospitals could restart their elective services, most likely since there was a relative overcapacity of staff in anticipation of a continued pandemic.

We conclude that the impact of COVID-19 on pediatric surgical procedures in Sweden during the first wave of the pandemic was dramatic, but elective services were restored a few months after the peak.

4.1 | Swedish perioperative registry

SPOR is a nonprofit organization and a branch of the Swedish Society of Anaesthesiology and Intensive Care Medicine. The registry itself is maintained by the Uppsala Clinical Research Centre and administered by a national board where the chairman of SPOR is ultimately responsible for data storage and its appropriate usage. Since its inception in 2011, the registry has grown from a few hospitals to nearly ninety as of 2019, thereby covering approximately 98% of all surgical procedures in Sweden. Data containing type of surgical procedure, duration of surgery and anesthesia, postoperative care, and any perioperative complications are recorded in the hospital unique operational planning system and then automatically reported to the national registry, on a daily basis.

Approximately, 600 000 surgeries are performed in Sweden on a yearly basis and divided between public and private hospitals in adult and pediatric populations. The majority of procedures are performed at public institutions, which are all part of the SPOR network. Regarding procedures requiring pediatric anesthesia, the majority are performed at our university hospitals and some county hospitals. Pediatric anesthesia in private practice is rare in Sweden except for simple office-based mostly ENT procedures.

4.2 | Time course of the pandemic and the effects on caseload

In our study, data were collected from the SPOR database in the early part of the pandemic, between weeks 3 and 34 in 2020 and compared with the same period in 2019. Our subsequent analysis was based on nearly 29 000 pediatric procedures (in weeks 12–26), which included nearly 90% of all pediatric anesthesia procedures performed in Sweden in 2020. The first case of COVID-19 in Sweden was confirmed on 31 January 2020, the first cases of indigenous spread were reported March 6th, the first death five days later. Hospitals responded quickly to the anticipated and real increase in caseload. The number of ICU beds in Sweden is among the lowest per capita in Europe, but through locally organized re-allocations, the ICU capacity was doubled on a national level and quadrupled in the most severely affected regions. As displayed in Figure 2, the number of pediatric procedures started plummeting in all three hospital categories in the second week of March, starting March 6, simultaneously with the first COVID-19 deaths in adults. For the purposes of this study, we defined the first wave as all consecutive weeks with more than 5% reduction in the total number of procedures. Interestingly, travel restrictions were initiated by the European Union on 17 March but the first major restrictions from the government were implemented toward the end of March, which is three weeks later than when hospitals started canceling elective cases.

4.3 | ENT/maxillofacial surgery

Previous studies have indicated that pediatric elective surgery has been completely discontinued, at least in the early parts of the pandemic.^{5,9-11} In our material, all categories were affected, but notably, the category of ENT and maxillofacial surgery was significantly reduced during the whole period, and the reduction during the peak week of April reached 86.7%. This is not surprising for a number of reasons. Firstly, the bulk of ENT procedures in children are such as grommets and adenoidectomy may often (but not always) be postponed several months or even years without serious harm to the child. Secondly, respiratory infections are common in this patient group and many procedures are aerosol producing, therefore, disqualifying surgery when symptomatic. Unfortunately, there is a lack of comparative data

concerning pediatric ENT surgery, but several reports from adult or mixed ENT departments are reporting similar reductions.¹¹⁻¹³ In an attempt to avoid unnecessary cancellations and thereby risking long term negative effects in patients, international guidelines have quickly been established to restart pediatric ENT surgery worldwide, but we are not aware of any such measures from professional organizations in Sweden.¹⁴

4.4 | Orthopedic surgery

The effects on pediatric orthopedic surgery were relatively mild during the study period, but this can probably be explained by the fact that the most common pediatric orthopedic procedures are emergency cases, such as arm fractures (Figure 3). In contrast, 75% of the responding pediatric orthopedic surgeons reported 75% reduction in activity in a survey from Turkey.¹⁵ A study from Finland reported a 31% reduction in orthopedic trauma procedures, and the authors postulated that this was partly attributed to severe restrictions, such as school closure and restriction of social gatherings.¹⁶ Similar reports of dramatically reduced orthopedic emergency caseload have been published from the United Kingdom and Italy, again in contrast to the results of the present study.^{17,18}

4.5 | General surgery

Despite the fact that hospitals will necessarily prioritize emergency care, several authors report that urgent medical conditions in children are also being delayed, potentially with severe consequences.¹⁹⁻²¹ In our material, it is difficult to draw any conclusions with certainty, but overall, there has been an increase in emergency general surgery, and only a modest decline in emergency cases related to ENT and orthopedics. It is possible that the number of children seeking emergency care in Sweden during the pandemic has remained steady, most likely on account of keeping schools open and less restrictions in regard to children's social activities. From a strictly pediatric perspective, there are many other advantages of keeping schools open, albeit spread of the virus is likely to occur in educational settings.²² This is a challenge for countries that have included the closing of schools in their lockdown strategies and are now struggling with optimal timing for re-opening them.^{23,24}

Despite measures to restart surgical services in individual medical centers, the majority of hospitals are still in the process of exclusively providing emergency care at the end of 2020. It is unclear how fast and to what degree pediatric surgical capacity has recovered in different countries, but our data show that regarding pediatric services, Sweden returned to near normal capacity within 3 months of the start of the first wave and maintained near-normal levels of emergency care related to general surgery and orthopedics during the entire first wave of the pandemic. A possible explanation is that pediatric centers adapted rapidly to the pandemic, implementing

strict algorithms for testing children scheduled for surgery, similar to other published data.²⁵⁻²⁷ Furthermore, compared with adult services, it is our impression that pediatric centers may have been relatively less taxed by allocation of staff to COVID-19 wards and intensive care units. Having said this, the SPOR data indicate that the second wave of the pandemic may have started to have effects on the healthcare system as early as a few months after returning to normal in June (Figure 1). Future studies should focus on the effects of the continued spread of the disease and healthcare services.

The Swedish strategy to reduce the spread of the pandemic developed and communicated by the Public Health Agency has been different from those of other countries. The focus of issued recommendations was mainly on hand hygiene and voluntary social distancing. There were no hard lockdowns, primary and secondary schools were left open, and measures such as travel restrictions, quarantine, and social distance rules were recommended rather than enforced. Furthermore, re-organization of hospital services to accommodate the increasing number of patients in wards, intermediate care units, and ICUs was almost entirely driven and accomplished by the hospital staff in communication with departmental management and hospital boards, that is, not as a response to governmental orders or national professional bodies, which may have been the key to the rapid changes. While some selected community measures and events together with the weekly COVID-19 death rate are summarized in Table 3, it is not within the scope of this paper to comprehensively describe or analyze the effects on the pandemic in the community as a whole. There is no doubt that the mortality due to COVID-19 has been much higher compared with the neighboring Nordic countries. In fact, overall COVID-19 mortality was among the highest in the world during the first wave. In spite of the much-criticized short-comings of the elderly care resulting in high death rates, our data suggest that hospital-based health care seems to have coped comparably well, supported by a recent report of a decrease in overall 60-day mortality in hospitalized COVID-19 patients from 24.7% in March 2020 to 10.4% postwave.²⁸

4.6 | Limitations

As everyone is aware of (in March 2021), the pandemic is not over yet and the results in the present study may not be valid for the second or third wave of the pandemic. However, we think it is valuable to publish the effects so far, to facilitate comparisons of national outcome data in regard to pediatric surgical capacity.

Although SPOR aims at complete coverage of all surgical and anesthetic procedures in Sweden, we discovered that one of the four major pediatric hospitals did not enter data into the registry. We double-checked for other missing data and found that three district hospitals and one county hospital joined SPOR too late to provide complete data for the study and have, therefore, been excluded. Fortunately, the annual number of procedures in the above five hospitals amounts to approximately 8000 (roughly 12% of the total number of annual procedures) and is, therefore, not likely to

have had a major impact on the results. Concerted efforts have been initiated to convince the missing pediatric centers to join the registry to ensure complete national datasets in future studies.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

PF and GE involved in study conception and design. JA, SM, and PF wrote the paper. All authors involved in analysis, editing and approval of the paper. SM and JA shared the first author position.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, [PF], upon reasonable request.

ORCID

Gunnar Enlund  <https://orcid.org/0000-0001-9438-3644>

Peter Frykholm  <https://orcid.org/0000-0001-6402-136X>

TWITTER

Peter Frykholm  @FrykholmPeter

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