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Pediatric surgical wait priority score (pSWAPS): Modifying a health system's adult-based elective surgery prioritization system for children's surgery during the COVID-19 pandemic

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ABSTRACT

Background: With the rise of COVID-19 cases, societies recommended canceling all elective surgical procedures because of perioperative concerns, transmission risk, and the need to divert resources. Once the number of cases stabilized, there was recognition that a system was needed to triage and prioritize scheduling operations.

Methods: A universal scoring system to triage surgical elective cases was developed for the Advocate Aurora Health system (Surgical Wait Priority Score, SWAPS) and was modified for use in pediatrics (pSWAPS). Resource-related, patient-related, and case urgency factors were used to create the overall score. Interrater reliability of ten cases was determined by four surgeons' scores and calculating Fleiss' Kappa coefficient. The system has been used for two months at two operating rooms with different resource restrictions with the goal of prioritizing elective cases.

Results: 18 factors were identified as significant contributors to the pSWAPS creating a cumulative score ranging from 0 to 120. In the first month, 61 and 99 procedures were screened at the Oak Lawn (OL) and Park Ridge (PR) campuses respectively, and in the second month, 94 (OL) and 135 (PR) procedures were evaluated. The average pSWAPS scores were 37.9 at OL and 54.3 at PR. All cases that had scores within the immediate group were scheduled and completed.

Conclusion: The pSWAPS system is a simple, flexible scoring system that takes into consideration resource constraints. pSWAPS has been used for two months. It has served as an effective tool for safe and methodical reintroduction of elective procedures during the COVID-19 pandemic and could be used again for another surge.

Level of evidence: prognosis study, level of evidence - 4.

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1. Introduction

In late December, reports of a novel coronavirus SARS-coV-2, or COVID-19, leading to a severe respiratory distress syndrome began to emerge from China and then quickly expanded to the United States. By March, the number of cases escalated exponentially, and the outbreak was classified as a pandemic by the WHO [1]. The main focus of healthcare systems centered on delivery of care to cohorted intensive care patients with COVID-19 as well as the safeguarding of adequate personal protective equipment (PPE) and ventilators. Due in part to hospital systems being overwhelmed and scarcity of resources, the American College of

Surgeons and other professional societies recommended canceling all elective cases in mid-March [2]. The rationale for stopping elective cases was because of perioperative concerns [3,4], the risk of transmission to the operating room staff, and the need to divert resources to treat COVID-19 patients (personnel, intensive care beds, PPE, testing materials). A number of adult studies reported significant postoperative morbidity, especially pulmonary complications, and mortality in patients with COVID-19 undergoing surgical procedures. It is unknown if the same risks pertain to the pediatric population given the lack of data. The Advocate Aurora Health system followed these recommendations and halted all nonemergent operations at the hospitals.

Once the number COVID-19 cases began to stabilize, there was recognition that a system needed to be developed to triage and prioritize scheduling of operations once it was felt safe to restart performing "elective" surgical procedures. Our hospital system developed a framework to prioritize surgical operative cases tak-

Abbreviations: SWAPS, surgical wait priority score.

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Table 1

Interrater reliability assessment using the pSWAPS system. To validate the pSWAPS system, 10 elective cases were described with brief clinical vignettes and then scored by 4 independent surgeons. The resulting scores, shown above, were used to determine inter-rater reliability by calculating Fleiss' Kappa. There was strong agreement among independent surgeons in determining that a case did not qualify for scheduling, but less strong agreement among surgeons in determining if a case qualified for immediate or future scheduling. *I* = Immediate, *F* = Future, *N* = not qualified.

Surgeon:	Example 1	Example 2	Example 3
Patient:			
Surgical Case:			
A. Pediatric Resource/Procedure Factors			
Intra-Operative Variables:			
Incision-Closure >120	0	0	1
LOS >24 hrs	0	1	1
OR staff >2	0	1	1
Total Score	0	2	3
Risk Stratification	Low	Medium	High
Peri-Operative Variables:			
General anesthesia	0	1	1
ICU Stay post op	0	1	1
Abd-pelvic/Thoracic/Upper GI/Head and Neck	0	0	1
Covid+/Sx's/Known Exposure W/I 14 days	0	0	1
Total Score	0	2	4
Risk Stratification	Low	Medium	High
Total Resource/Procedure Factors	0	4	7
A. Resource/Procedure Score	0	10	20
B. Pediatric Risk/Patient Factors			
Anesthesia Variables			
age < 6 mos	0	1	1
chronic lung disease/ pulmonary hypertension	0	1	1
DM	0	0	1
congenital heart disease	0	0	1
immunocompromised	0	0	1
Total Score	0	2	5
Risk Stratification	Low	Medium	High
Pulmonary/Covid Variables			
OSA / CPAP	0	1	1
Asthma/ Congenital Emphysema	0	1	1
Home O2	0	0	1
Covid+/Sx's/Known Exposure W/I 14 days	0	0	1
PE/DVT within 12 months	0	0	1
Total Score	0	2	5
Risk Stratification	Low	Medium	High
Total Risk/Patient Factors	0	4	10
B. Risk/Patient Factor Score	0	10	20
C. Pediatric Priority/Case Factors			
Impact of > 4week delay on disease/procedure			
Low - No Worse	high	medium	low
Medium - Moderately Worse			
High - Significantly Worse			
C. Priority/Case Score	0	40	80
Total Risk Stratification Score(A + B + C)	0	60	120
Status:	Qualifies for immediate scheduling date	Qualifies for future scheduling date	Does NOT Qualify for scheduling

IDPH. Therefore, we decided to use the same set of adult SWAPS variables for the pSWAPS, but to decrease the overall weight of the resource-related factors in the overall score (from 33.3% to 16.7%).

In calculating the resource subscore, a single point was given for each of the following resources: time greater than 120 min, length of stay greater than 24 h, OR staff greater than 2 people, general anesthesia, ICU bed needed, aerosolizing procedure, COVID positivity or exposure / negative pressure room requirement. Resource subscores of 0 were assigned a weight of 0 in the overall pSWAPS score; subscores of 1–4 were assigned a weight of 10 in the overall pSWAPS score; and subscores 5–7 were assigned a weight of 20 in the overall pSWAPS score.

2.2. Patient related factors

Comorbid conditions, including COVID-19 infection, affect surgical outcome. If a patient was expected to do poorly in and after surgery (and ultimately require greater hospital resources), that patient's case was given lower priority. Therefore, the next section of the adult SWAPS score was determined by patient-related comor-

bidities. In the development of the corresponding pSWAPS score, pediatric-specific analogous conditions were used. Age less than 6 months, chronic lung disease, diabetes mellitus, congenital heart disease, difficult airway, and an immunocompromised state were considered anesthesia-risk factors; and CPAP use, asthma, home oxygen use, COVID-19 exposure, and DVT/PE history were considered COVID-19 specific variables that would potentially further complicate outcome if the child were to become infected. Because the association between these comorbidities and poor surgical outcomes in children is less clear than in adults [8], the patient-related factors were weighted less in the overall score for children (from 33.3% to 16.7%).

In calculating the patient subscore, a single point was given for each of the following conditions: age less than 6 months, chronic lung disease, diabetes, congenital heart disease, immunocompromised state, CPAP use, asthma, home oxygen, COVID positivity or exposure, DVT/PE. Patient subscores of 0–2 were assigned a weight of 0 in the overall pSWAPS score; subscores of 3–4 were assigned a weight of 10 in the overall pSWAPS score; and subscores 5 or greater were assigned a weight of 20 in the overall pSWAPS score.

Table 2

Case vignettes for determination of interrater reliability.

The following 10 patients from the pediatric ENT service were scheduled for surgery on an elective basis when COVID19 restrictions began, and their cases need to be prioritized. Please review the following case summaries and then use the tool to assign a score for prioritizing scheduling.

1 EL

7-month-old female with no past medical history aside from recurrent acute otitis media. The patient has been treated 3 times over 2 months for ear infections, with PO antibiotics x 2 and IM antibiotic x 1. Ear infections complicated by bilateral tympanic membrane perforations x 2. Now intact TMs and serous effusions. Passed newborn hearing test. No COVID exposure, no comorbidities.

1 TJ

14-year-old male with recurrent streptococcal tonsillitis. The patient had 5 episodes of streptococcal tonsillitis this year, 7 episodes last year, all uncomplicated. No snoring, no solid food dysphagia. No middle ear disease. No COVID exposure, no comorbidities.

1 HK

8-year-old female with recurrent acute otitis media. Patient has had 8 ear infections in the last year, 6 ear infections in the last 6 months, most recently 1 month ago. Patient has multiple antibiotic allergies, but has not had complications from treatment. No speech delay, no concerns for hearing loss. No COVID exposure, no comorbidities.

1 SS

15-year-old male with Down Syndrome, obstructive sleep apnea on home oxygen who has had adenotonsillectomy previously, and is scheduled for lingual tonsillectomy. Patient has AHI of 33, no significant desaturations with nasal cannula oxygen, but CO₂ retention which is moderate. History of congenital heart disease, no significant pulmonary hypertension. No obstructive symptoms during the day. Possible COVID exposure last week.

1 DW

25-month-old female with speech delay, concern for global developmental delay. Passed a universal newborn hearing screen, but has failed 3 hearing tests since then. Patient has chronic otitis media with effusion bilaterally, with air thresholds bilaterally in soundfield at 50 to 60 dB. No ear infections, never otorrhea. Does not tolerate hearing aids. No COVID exposure, no comorbidities.

1 JJ

14-year-old female with tympanic membrane perforation which is large, cholesteatoma which is infected. Chronically draining ear which is persistent despite treatment with IV antibiotics. Does not have ear pain, does have tinnitus and occasional dizziness. No facial nerve involvement. This is longstanding, but clearly worse in the last 2 months. No COVID exposure, no comorbidities.

1 HA

2-month-old female with failure to thrive (less than 1st percentile for weight), severe congenital laryngomalacia with AHI of 38. Patient had multiple cyanotic spells which have led to Emergency room visits, no cyanosis at baseline. On home oxygen. Patient has been treated with antireflux medication and has not improved. Has aspiration with thin liquids and has an ngt in place. No COVID exposure, no comorbidities.

1 AA

4-year-old male with obstructive sleep apnea. Patient has 4+ tonsils, severe adenoid hypertrophy, AHI of 50. Does not tolerate CPAP or home oxygen. Otherwise healthy. No COVID exposure.

1 MO

8-year-old male with known subglottic stenosis. Patient has required balloon dilation for subglottic stenosis 2 times, and responded well to those dilation, but has slowly had increasing stridor and dyspnea with exertion over the course of the last 3 months. X-ray concerning for persistent/recurrent subglottic stenosis. Father with COVID test confirmed positive 1 week ago, no comorbidities.

1 VS

21-month-old female with tracheostomy who has granulation tissue inferiorly which has not responded to medical therapy. Patient has granulation tissue near the tip of the tracheostomy tube which is persistent despite change of the tracheostomy tube length. Is able to ventilate normally, without hypercapnia or respiratory distress. Is on the vent 24/7. Has global developmental delay, CP, no congenital heart disease. No COVID exposure.

2.3. Case urgency/disease-related factors

The dominant factor in the determination of the pSWAPS score was the case urgency. This was determined by the surgeon and was a judgment on the risk presented by delaying the case.

The overall weight of the case urgency subscore was 66.7% in the pSWAPS scoring system, which was double that of the adult system. The result was that all pediatric cases for which an impact of delay was low received high overall pSWAPS scores and were not candidates for scheduling. This was fundamentally different from the adult scoring system, in which a patient with low impact of delay *would* be scheduled if the resource- and patient-related factors were favorable. Conversely, pediatric patients with the highest risk of harm from delay would be scheduled regardless of the other subscores, while adults with highest risk of harm from delay would only be scheduled if the resource- and patient-related factors were favorable.

To calculate the case urgency subscore, the surgeon or proxy was asked to simply predict the impact of delay of 4 weeks. If the impact of delay of greater than four weeks was high, a score of 0 was assigned for the case urgency sub-score. If the impact of a four week delay was considered moderate, a score of 40 was assigned. If the impact of a four week delay was considered low, a score of 80 was given.

2.4. Overall pSWAPS determination

The overall pSWAPS score for each case was determined by adding the resource-, patient-, and case urgency subscores, resulting in an overall score between 0 and 120. Initially, overall scores of 0–20 were considered for immediate scheduling. Initially, overall scores of 30–60 were considered for future scheduling (placed onto the schedule but not preferentially in the first 4 weeks). Cases with pSWAPS scores greater than 70 were not scored initially if there were significant resource restraints. As resources became more available during the pandemic, cases with higher scores were considered for scheduling. Each operating room site considered the number of available rooms each week to determine what the cut-off scores would be for scheduling.

2.5. Determining the validity and interrater reliability of the pSWAPS score

Because of the significant risk of subjectivity that was introduced by weighting urgency highly, interrater reliability was determined and all submitted scores were subject to review by a committee of physicians.

To determine interrater reliability, pSWAPS scores were determined by four independent providers of a single surgical specialty

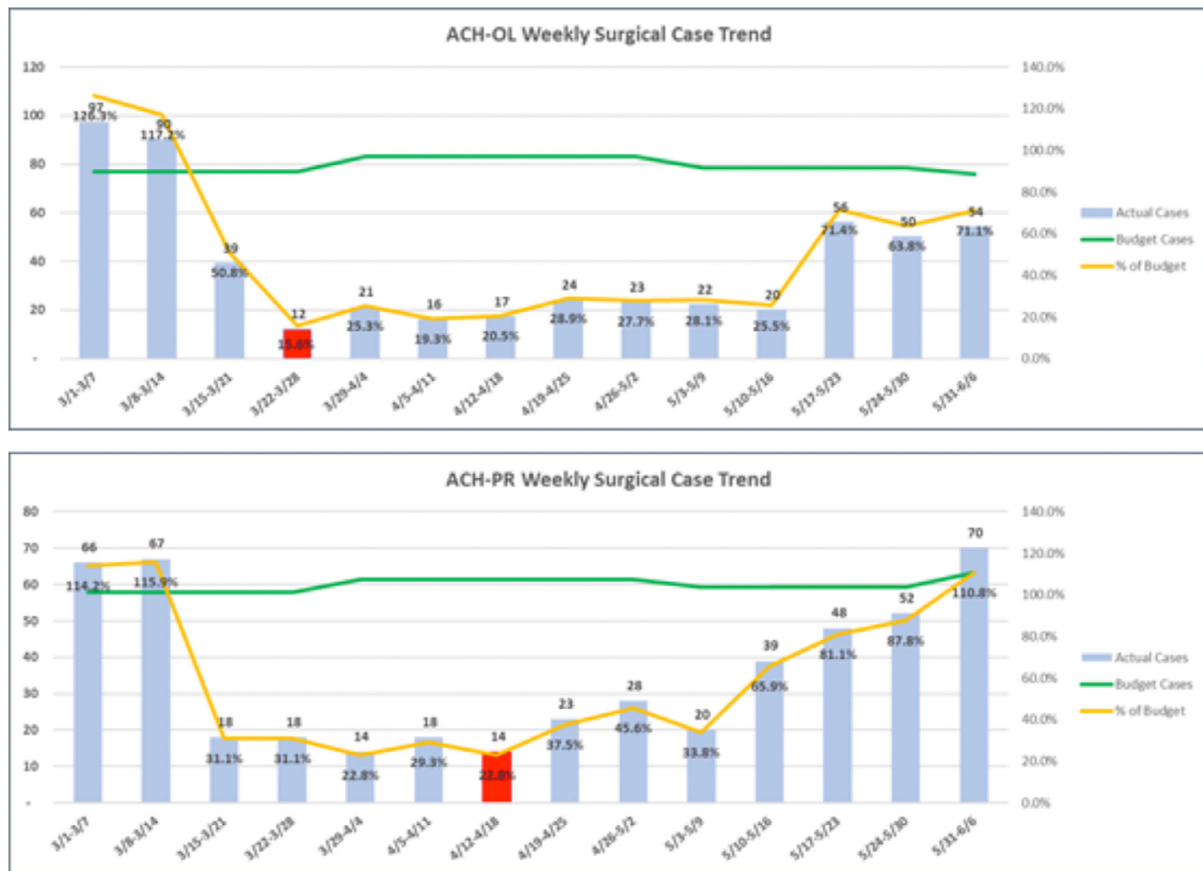


Fig. 2.. Surgical case trends at the two Children’s Hospitals during the time period. The red bars indicate the week of lowest case numbers.

for each of ten actual surgical patients whose case was delayed by COVID-19 restrictions using brief clinical vignettes. Fleiss’ Kappa coefficient was calculated, using the nominal outcomes of “qualifies for immediate scheduling,” “qualifies for future scheduling,” and “does not qualify for scheduling.” The case vignettes are presented in Table 2.

To ensure that scores were being appropriately assigned on an ongoing basis, a committee of surgeons, hospitalists, and intensivists reviewed the cases for approval biweekly after the pSWAPS form had been submitted, as directed by the IDPH. The system has been used for approximately two months since the reactivation of elective surgical cases.

3. Results

18 factors were identified as significant contributors to the pSWAPS scoring system creating a cumulative score ranging from 0 to 120, with the most urgent cases receiving the lowest score. These factors were created by a working group of surgeons, anesthesiologists, nurses, and leadership members. In the first month of reactivation (05/03/20–06/03/20), 61 and 99 elective procedures were evaluated using the scoring system at the Oak Lawn (OL) and Park Ridge (PR) campuses respectively, and in the second month (06/04/20–06/24/20), 94 (OL) and 135 (PR) procedures were evaluated. The total number of pediatric cases done during these times were 85 and 250 at OL and 229 and 195 at PR (Fig. 2, Table 3). The average SWAPS scores were 37.9 at OL and 54.3 at PR. The average pSWAPS scores increased from 30.4 to 42.4 in OL and from 38.2 to 70.4 in PR. No patients that were screened and had a score within the immediate group had their operations deferred. In addition, no

Table 3

Numbers of patients evaluated by the pSWAPS system at each Children’s hospital.

	05/03/2020 - 06/04/2020	06/04/2020 - 06/27/2020
Park ridge		
Total Peds surgeries	229	195
Total based on screening tool:	94	135
Emergent/essential cases	135	60
Total number of I cases	6	10
Total number of F cases	15	25
Total number of N cases	73	100
Oak Lawn	05/03/2020 - 06/04/2020	06/04/2020 - 06/27/2020
Total Peds surgeries	85	250
Total based on screening tool:	61	99
Emergent/essential cases	59	57
Total number of I cases	45	73
Total number of F cases	19	43
Total number of N cases	7	24

urgent operative intervention because of deferment of an elective operation occurred during this timeframe.

During the first and second months of reactivation in OL, 181 and 393 procedures were completed on adults. During the first and second months of reactivation in PR, 517 and 715 procedures were completed on adults. Thus, the fraction of cases that were completed on children rose from 14% to 27% in OL and 15% to 19% in PR when comparing the 12 months prior to the pandemic to the early reactivation phase.

To determine interrater reliability, ten cases were reviewed by four separate children’s surgeons and scored using the pSWAPS system. Results are shown in Table 1. Fleiss’ Kappa was calculated. K_i (for immediate scheduling) was 0.278 (p = 0.03); K_f (for future

scheduling) was 0.231 ($p = 0.07$); and K_N (for not qualified) was 0.739 ($p = 1.06E-08$). Fleiss' Kappa was calculated to determine the interrater reliability using four independent raters. Fleiss' K values of 0.21–0.4 are generally considered “fair agreement.” K_N (for not qualified) was 0.739 ($p = 1.06E-08$). K values of 0.6–0.8 are generally considered “substantial agreement.”^[9]

4. Discussion

We have described a scoring system for elective surgical procedures that incorporates the hospital resources and limitations as well as patient and surgical factors. The system can be adjusted depending on resource utilization requirements. The scoring system is not meant to be a detailed ranking method, but instead to serve as a decision making tool to group the procedures into categories of immediate scheduling, future scheduling, and not qualified for scheduling, taking a number of factors into account. In this manner, it simplifies the difficult task of determining which surgical procedures should be done first, and allows for comparison across subspecialties and to adult surgical cases.

The scoring system has been used effectively at two medical centers within a larger health system that have the complicated undertaking of providing care to both children and adults. The availability of resources for children compared to that of adults was greater at both sites, essentially because there were fewer restrictions at the level of the state and more available beds and providers. A fundamental change to the scoring system that allowed children's cases to be scored among adult cases was adjusting the weight in the overall score of the resources required to match the resources available. As the weight given to resource restraints was decreased for children, a greater weight was given to the surgeon-determined urgency of the case for children.

The result of the change was that pediatric cases made up a higher fraction of overall surgical cases in the first months of reactivation in the pandemic. In OL, that fraction rose from 14% in the 12 months prior to the pandemic to 27% during the early reactivation phase. In PR, the fraction rose from 13% to 19%.

An important difference between the two sites was the COVID-19 burden in the surrounding communities. At the peak of the pandemic, the burden in OL was significantly higher compared to that of PR. In the ACH-OL and PR Hospital systems, there were approximately 3100 and 1300 COVID positive patients (including both adults and pediatric patients) respectively during the time-period studied. In OL, operating room nursing staff was diverted to assist with adult intensive care units. As a result, fewer elective cases were done in OL compared to PR during early reactivation, despite the fact that the overall surgical volumes in OL are typically higher, both for children and adults. Because of the relatively limited capacity in OL, average pSWAPS scores at that site were lower during reactivation as well. As the COVID-19 burden decreased and more capacity was available, more cases were performed. An increase was noted in the second month on both campuses, and the percentage increase was greater in OL compared to PR. In addition, cases with a higher pSWAPS score were performed at OL during the second month of reactivation.

A significant concern that our institution had in assigning greater weight to surgeon-determined urgency for children's cases was that it would make the overall score more subjective. To address this, ten elective cases which had been scheduled by a single provider and canceled because of COVID-19 restrictions in March were summarized with brief clinical vignettes, and these were then rated by four children's surgeons of the same subspecialty (pediatric otolaryngology) using the pSWAPS system. Our interpretation of the Fleiss' Kappa results is that independent surgeons within a single specialty largely agreed on whether a case qualified or did not qualify for scheduling, using the pSWAPS tool. Those same sur-

geons, however, did not clearly agree on whether or not the case qualified for immediate or future scheduling using this tool. Ultimately, despite the subjectivity introduced by a greater weight given to case urgency in the case of children, the tool was consistently useful in identifying cases appropriate for scheduling during reactivation.

There are a number of limitations to this scoring system. One of the main shortcomings is the fact that the system was not widely validated across specialties prior to its implementation given the time constraints. In addition, there was no differentiation in the variables for different service lines or surgical subspecialties. Although this aids in the simplicity and transparency of the approach, there may be some nuances of different specialties that are not adequately accounted for. There also is not significant data known about comorbidities and perioperative outcomes in pediatric patients with COVID-19. As such, there may be other patient-related factors that were not addressed.

The advantages of this scoring system include its flexibility, simplicity to use, broad applicability, and objectiveness to facilitate decision-making. It provides a more objective measure for allotting operating room time and mitigates problems of using more of a free-for-all and first-come-first-serve type of approach. In addition, as both adults and children use the operating rooms at both of the hospitals where the scoring system was used, the SWAPS system allows for some type of comparison if required to demonstrate which patient would be allowed to be operated on first.

5. Conclusions

The pSWAPS system is a simple, flexible scoring system that takes into consideration resource constraints, pediatric specific conditions that may contribute to perioperative risk if affected with COVID-19, and the procedure acuity. It has been used for the two months of reactivation in the operating room for elective cases. It has served as an effective tool assisting with a safe and methodical reintroduction of elective procedures during the COVID-19 pandemic and could be used again if another surge occurs.

Declaration of Competing Interest

Nothing to disclose. Disclosures not related to this work: Dr. Slater is a consultant for Boulder Surgical. This disclosure is not relevant for this manuscript.

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