Journal Pre-proof

Pediatric Surgical Waitlist in Low Middle Income Countries during the COVID-19 Pandemic

Greg Klazura, Paul Park, Ava Yap, Ruth Laverde, Emma Bryce, Maija Cheung, Ernestina Bioh, Sacha Hamilton, Phyllis Kisa, Nasser Kakembo, Michele Ugazzi, Martin Situma, Eric Borgstein, Miliard Derbew, Samuel Negash, Amezene Tadesse, Bruce Bvulani, Bertille Ki, Tapsoba Toussaint, Zaitun Bokhary, Godfrey Sama Philipo, Emmanuel Ameh, Mulenga Mulewa, Jonathan Mwansa, Ifeanyichukwu Onah, Vanda Amado, Daniel De Ugarte, Fabian Massaga, Samwel Byabato, Wasiu Lanre Adeyemo, Olugbemiga Ogunlewe, Bip Nandi, Doruk Ozgediz

PII: S0022-4804(23)00058-6

DOI: https://doi.org/10.1016/j.jss.2023.02.012

Reference: YJSRE 17968

To appear in: *Journal of Surgical Research*

Received Date: 5 December 2022

Revised Date: 18 January 2023

Accepted Date: 19 February 2023

Please cite this article as: Klazura G, Park P, Yap A, Laverde R, Bryce E, Cheung M, Bioh E, Hamilton S, Kisa P, Kakembo N, Ugazzi M, Situma M, Borgstein E, Derbew M, Negash S, Tadesse A, Bvulani B, Ki B, Toussaint T, Bokhary Z, Philipo GS, Ameh E, Mulewa M, Mwansa J, Onah I, Amado V, De Ugarte D, Massaga F, Byabato S, Adeyemo WL, Ogunlewe O, Nandi B, Ozgediz D, Pediatric Surgical Waitlist in Low Middle Income Countries during the COVID-19 Pandemic, *Journal of Surgical Research* (2023), doi: https://doi.org/10.1016/j.jss.2023.02.012.

Revised - Unmarked, January 13, 2023

Title: *Pediatric Surgical Waitlist in Low Middle Income Countries during the COVID-19 Pandemic*

Title: *Pediatric Surgical Waitlist in LMICs during the COVID-19 Pandemic*

Authors: Greg Klazura[1,2,], Paul Park[2], Ava Yap[2], Ruth Laverde[2], Emma Bryce[3], Maija Cheung[19] Ernestina Bioh[2], Sacha Hamilton[3], Phyllis Kisa[4], Nasser Kakembo[4], Michele Ugazzi[5], Martin Situma[6] , Eric Borgstein[7], Miliard Derbew[8], Samuel Negash[8], Amezene Tadesse[8], Bruce Bvulani[9], Bertille Ki[10], Tapsoba Toussaint[10], Zaitun Bokhary[11] , Godfrey Sama Philipo[11], Emmanuel Ameh[12], Mulenga Mulewa[13], Jonathan Mwansa[13], Ifeanyichukwu Onah[14], Vanda Amado[15], Daniel De Ugarte[15], Fabian Massaga[16], Samwel Byabato[16], Wasiu Lanre Adeyemo[17], Olugbemiga Ogunlewe[17], Bip Nandi[18], Doruk Ozgediz[2]

Affiliations: [1] University of Illinois at Chicago Department of Surgery, [2] UCSF Center for Health Equity in Surgery and Anesthesia, [3] KidsOR Research Team, [4] Mulago National Referral Hospital, [5] Hospital de los Valles, [6] Mbarara Referral Hospital, [7] Queen Elizabeth ENT, [8] Menelik II Hospital, [9] University Teaching Hospital, [10] Hôpital Pediatrique Charles De Gaulle, [11] Muhimbili National Hospital, [12] National Hospital Abuja, [13] Arthur Davison Children's Hospital, [14] National Orthopaedic Hospital, [15] Hospital Central de Maputo, [16] Bugando Medical Center, [17] Lagos University Teaching Hospital, [18] Kamuzu Central Hospital, [19] Yale University, Yale New Haven Hospital

Corresponding author:
Greg Klazura, MD, greg.klazura@gmail.com, +1-815-871-3014
Division of Pediatric Surgery
Department of Surgery
University of Illinois Hospital and Health Sciences System
840 S. Wood St. Ste 406 Chicago, IL 60612

Keywords: surgical waitlist, COVID-19, pediatric, surgery

Acknowledgements: KidsOR, UCSF Center for Health Equity in Surgery and Anesthesia, University of Illinois at Chicago Department of Surgery

Contribution Statement:

Authors: All authors discussed the results and contributed to the final manuscript.

- Greg Klazura, MD: Performed data analysis and wrote the manuscript.
- Paul Park, MD: Performed data analysis and wrote the manuscript.
- Ava Yap, MD: Performed data analysis and wrote the manuscript.
- Ruth Laverde, BS: Performed data analysis and wrote the manuscript.
- Emma Bryce, MPH: Provided logistical support for data collection, reviewed/edited the manuscript.
- Maija Cheung, MD: Reviewed/edited the manuscript.
- Ernestina Bioh, MD: Reviewed/edited the manuscript.
- Sacha Hamilton, BS: Reviewed/edited the manuscript.
- Doruk Ozgediz, MD: Supervised project and helped conceptualize the purpose of the manuscript.
- Phyllis Kisa, MD: Participated in data collection, survey implementation and survey design.
- Nasser Kakembo, MD: Participated in data collection, survey implementation and survey design.
- Michele Ugazzi, MD: Participated in data collection, survey implementation and survey design.
- Martin Situma, MD: Participated in data collection, survey implementation and survey design.
- Eric Borgstein, MD: Participated in data collection, survey implementation and survey design.
- Miliard Derbew, MD: Participated in data collection, survey implementation and survey design.
- Samuel Negash, MD: Participated in data collection, survey implementation and survey design.
- Amezene Tadesse, MD: Participated in data collection, survey implementation and survey design.
- Bruce Bvulani, MD: Participated in data collection, survey implementation and survey design.
- Bertille Ki, MD: Participated in data collection, survey implementation and survey design.
- Tapsoba Toussaint, MD: Participated in data collection, survey implementation and survey design.
- Zaitun Bokhary, MD: Participated in data collection, survey implementation and survey design.

- Godfrey Sama Philipo, MD: Participated in data collection, survey implementation and survey design.
- Emmanuel Ameh, MD: Participated in data collection, survey implementation and survey design.
- Mulenga Mulewa MD: Participated in data collection, survey implementation and survey design.
- Jonathan Mwansa, MD: Participated in data collection, survey implementation and survey design.
- Ifeanyichukwu Onah, MD: Participated in data collection, survey implementation and survey design.
- Vanda Amado, MD: Participated in data collection, survey implementation and survey design.
- Daniel DeUgarte, MD: Participated in data collection, survey implementation and survey design.
- Fabian Massaga, MD: Participated in data collection, survey implementation and survey design.
- Samwel Byabato, MD: Participated in data collection, survey implementation and survey design.
- Wasiu Lanre Adeyemo, BDS: Participated in data collection, survey implementation and survey design.
- Olugbemiga Ogunlewe, BDS: Participated in data collection, survey implementation and survey design.
- Bip Nandi, MD: Participated in data collection, survey implementation and survey design.

Abstract

Purpose: COVID-19 led to significant reduction in surgery worldwide. Studies, however, of the effect on surgical volume for pediatric patients in low- and middle-income countries (LMICs) are limited.
Methods: A survey was developed to estimate waitlists in LMICs for priority surgical conditions in children. The survey was piloted and revised before it was deployed over email to 19 surgeons. Pediatric surgeons at 15 different sites in 8 countries in Sub-Saharan Africa and Ecuador completed the survey from February 2021 to June 2021. The survey included the total number of children awaiting surgery and estimates for specific conditions. Respondents were also able to add additional procedures.
Results: Public hospitals had longer wait times than private facilities. The median waitlist was 90 patients and the median wait time was 2 months for elective surgeries.
Conclusion: Lengthy surgical wait times affect surgical access in LMICs. COVID-19 had been associated with surgical delays around the world, exacerbating existing surgical backlogs. Our results revealed significant delays for elective, urgent and emergent cases across Sub-Saharan Africa. Stakeholders should consider approaches to scale the limited surgical and perioperative resources in LMICs, create mitigation strategies for future pandemics, and establish ways to monitor waitlists on an ongoing basis.

Introduction

The COVID-19 pandemic has led to significant disruptions of healthcare systems worldwide, as hospitals had to reduce elective surgeries in the interest of infection control and resource conservation.[1], [2] Various studies have explored the impact of the case volume reduction in high-income countries (HIC) which relied on pre-existing operative data that are lacking in many low and middle income country (LMIC) health systems.[1] Specifically, recent studies on this topic are modeled from previously published surgical volume, which remains scarce in LMICs.[3]–[5]

Bickler et al. conceptualized "unmet need" for surgical care as the potentially treatable disability and premature death due to a surgical condition, measured in potential DALYs averted.[6] Poenaru et al. further introduced the concept of "delayed/prevalent unmet need" i.e.patients who missed an earlier timely intervention due to inadequate coverage and illustrated how quickly the backlog can increase in health systems with limited resources.[7] Prior to the COVID-19 pandemic, Ullrich et al. found the "unmet need" in Uganda was 188,913 DALYs, meaning only 2.2% of the treatable burden of pediatric surgical disease received care.[8] Similarly, Cairo et al. calculated 3304 DALYs of met need compared to 25,577 DALYs' of unmet need in Kampala, Uganda.[11]

Within pediatric surgical disease, this distinction is important as the disability from untreated surgical disease can worsen over time and render even delayed surgical intervention ineffective.[7] As the unmet need or backlog grows, delayed care becomes more complex and costly, or potentially futile, thus increasing the pool of "unmeetable need". Therefore, estimates of unmet need and unmeetable need can be much greater and have larger variation due to the age limits of corrective surgery.[7] This is further exacerbated in LMICs where surgical care is limited and where 99% of global neonatal deaths occur.[8]

The COVID-19 pandemic has inherently created backlogs worldwide; in Ontario, the estimated backlog clearance time was 84 weeks for 148,364 surgeries, among which 14,351 were pediatric cases.[9] There is, however, a lack of primary literature focused on the impact of the pandemic on the surgical unmet need or backlog in LMICs, especially in pediatric surgery.[8], [10], [11] Estimates of the surgical backlog can be a key metric of unmet need since national and regional registries in LMICs are often absent.

In this study, we aim to estimate the backlog and characterize the waitlist of pediatric surgical cases in LMICs during the COVID-19 pandemic. Kids Operating Room (KidsOR) is a non-governmental organization that installs operating rooms at LMIC partner sites and also supports surgical and anesthesia training.. They aim to strengthen and build health system capacity in LMICs. As part of their mission, KidsOR also funds and supports data collection at partner sites to drive evidence-based advocacy and quality improvement.

Methods

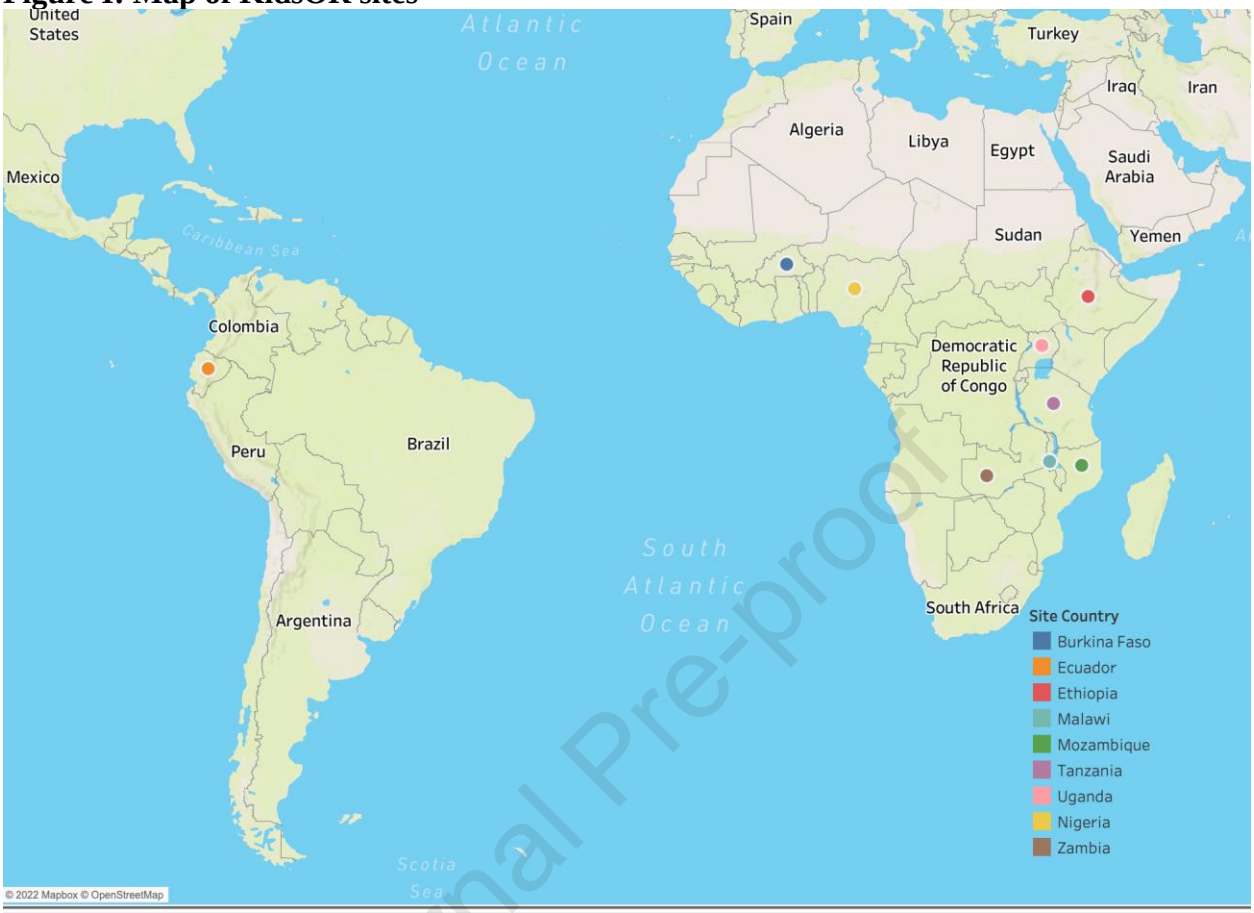
KidsOR has Memorandums of Understanding and University of California, San Francisco (UCSF) Institutional Review Board approval at every site. In collaboration with LMIC providers,

the KidsOR research team co-developed an on-line survey tool to estimate existing pediatric surgery backlog overall and for specific conditions, mainly elective or semi-elective conditions. This was piloted with 5 sites, revised, and validated. The survey tool provided estimates of the total number of children waiting for surgery at their facility. Providers were then asked to approximate waitlists for specific surgical procedures: (1) “Hernia or Hydrocele Repair,” (2) “Orchiopexy,” (3) “Ano-plasty or Pull-Through,” (4) “Stoma Closure,” (5) “Hypospadias Repair,” (6) “Tumor Resection,” (7) “Cleft Lip or Palate Repair,” (8) “Burn Contracture Release,” and (9) “Hydrocephalus.” Providers were given a list of dropdown options to approximate the wait time for each procedure: < 2 weeks, 2-4 weeks, 1-3 months, 3-5 months, 6 months - 1 year, 1-2 years, and finally >2 years. Respondents were also able to add any additional surgical procedures that were not listed but had a significant waitlist. In addition respondents were given the opportunity to leave additional comments on the survey and barriers to care at the end of the questionnaire.

The online survey software Qualtrics XM Platform (Qualtrics, Provo, UT) was used to distribute the survey in English, Spanish and French. The KidsOR research team piloted the survey and then distributed it to each principal investigator at KidsOR partner sites. A PDF version of the survey was also provided in case the online survey was not accessible. Pediatric surgeons at 15 different sites in 8 countries in Sub-Saharan Africa and Ecuador completed the survey from February 2021 to June 2021:

1. Mulago Hospital - Uganda
2. Hospital de Los Valles - Ecuador
3. Mbarara Hospital - Uganda
4. Queens ENT - Malawi
5. Menelik II Referral Hospital - Ethiopia
6. University Teaching Hospital - Zambia
7. CHU Pédiatrique Charles de Gaulle - Burkina Faso
8. Muhimbili National Hospital - Tanzania
9. National Hospital Abuja - Nigeria
10. Arthur Davison Children's Hospital - Zambia
11. National Orthopedic Hospital Enugu - Nigeria
12. Maputo Central Hospital - Mozambique
13. Bugando Hospital - Tanzania
14. Lagos University teaching Hospital - Nigeria
15. Kamuzu Lilongwe - Malawi

Figure I: Map of KidsOR sites



Descriptive analysis was performed on the wait time, waitlist size, case type, and total case numbers using the online data visualization platform Tableau (Tableau Software, Inc., Seattle, WA) and Excel.

Results

Elective Cases

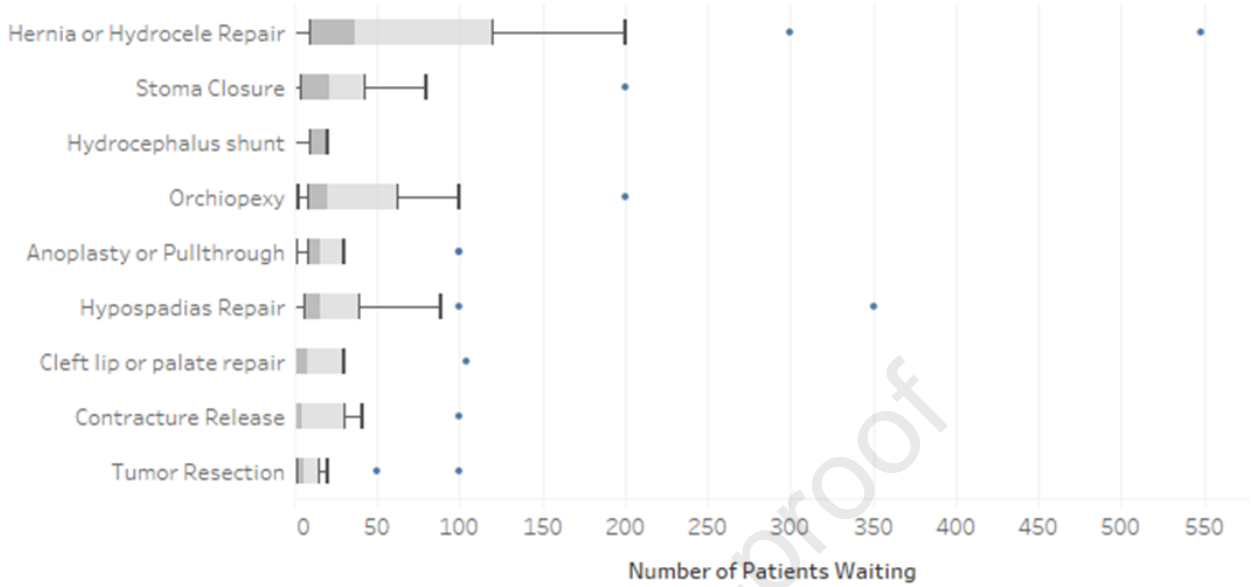
Waitlist size and time varied greatly in our study. In Burkina Faso at CHU Pediatric Hospital 2500 children are waiting for surgery while in Ecuador at De Los Valles Hospital, a private hospital, only 8 patients were noted to be waiting for surgery. The median wait time for surgery was two months across all sites with the longest wait time at Kamuzu Central Hospital in Malawi where the wait time was estimated to be more than three years.

Table 1: Waitlist size

Site	All Elective Surgery	Anoplasty/Pullthrough	Burn Contracture	Cleft Lip/Palate	Hernia/Hydrocele	Orchiopexy	Hydrocephalus Shunt	Stoma Closure	Tumor Resection	Hypospadias
Charles de Gaulle	2,500	100	100	30	200	100		80	100	100
Arthur Davison	1,640	23	41	104	548	20	19	47	4	88
Mulago	1,070	100			120	200		200	50	350
University Teaching	600	30	20	30	300	100	20	30	20	30
Mbarara	250	30			72	20		40	6	40
Muhimbili	158	15			25	25		30	6	15
Lagos University	104	10	4	10	36	12		4	12	8
Kamuzu	90									15
Maputo	72	12			36	6		12	2	3
Bugando	72	16	1	5	4			12	6	
Menelik II	70	5			10	20		5		30
Abuja	49	8		0	22	2		0	0	7
Queens ENT	21									
Enugu (Orthopedic)	20		2	2	0				2	1
De Los Valles	8	1	0	0	2	2	0	1	0	0
Median	**90**	**15.5**	**4**	**7.5**	**36**	**20**	**19**	**12**	**6**	**15**
Minimum	**8**	**1**	**0**	**0**	**2**	**2**	**0**	**1**	**0**	**0**
Maximum	**2500**	**100**	**100**	**104**	**548**	**200**	**20**	**200**	**100**	**350**
Interquartile Range	**365.5**	**20.5**	**29**	**28.5**	**110**	**53.5**	**10**	**37**	**12**	**33**

Each column is waitlist size organized by site and procedure. The columns are heat maps, dark red is a higher number.

Figure II: Box and Whisker Plot of Waitlist Size



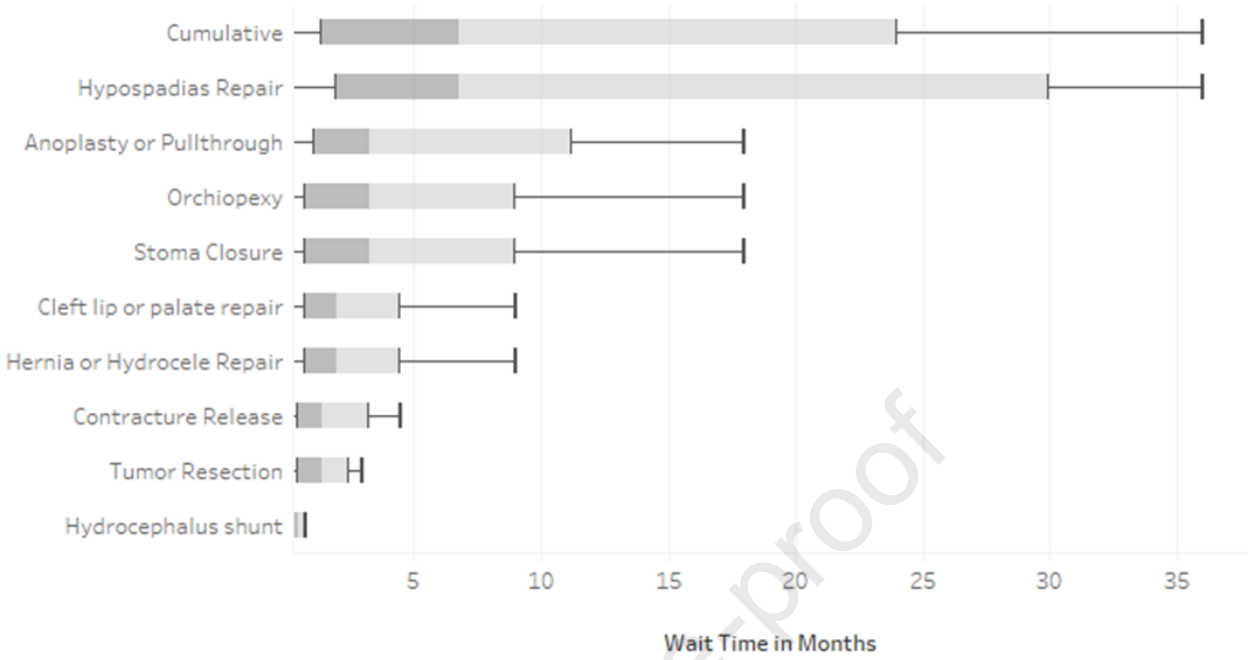
The box and whisker plot demonstrates the waitlist range across sites for common pediatric surgical diagnoses. The gray boxes depict the 25th to 75th %ile, while the whiskers range from 5th to 95th %ile. Blue dots show outliers.

Table 2: Wait-time

Site	All elective surgery	Anoplasty/Pull-through	Burn contracture release	Cleft lip/palate	Hernia/hydrocele	Orchiopexy	Hydrocephalus	Stoma closure	Tumor resection	Hypospadias
Kamuzu	36									
Mulago	30	18			9	18		18	3	30
Bugando	18	4.5	0.25	0.75	0.75			2	2	
Charles de Gaulle	9	18	4.5	9	9	9		4.5	0.75	36
Lagos University	4.5	4.5	2	2	4.5	9		9	2	4.5
University Teaching	2	4.5	2	4.5	2	2	0.75	2	0.75	4.5
Menelik II	2	2			2	2		2		2
Mbarara	2	4.5			2	2		4.5	0.75	9
Maputo	2	2			4.5	4.5		4.5	0.25	9
Arthur Davison	2	4.5	4.5	4.5	2	0.75	0.75	9	0.25	4.5
Abuja	2	2		0.25	0.25	0.75		0.75	0.25	2
Muhimbili	0.75	2			0.75	2		2	0.75	2
Enugu (Orthopedic)	0.75		0.75	0.25	0.25				0.25	0.25
Queens ENT	0.25									
De Los Valles	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Median	**2**	**4.5**	**2**	**1.375**	**2**	**2**	**0.75**	**3.25**	**0.75**	**4.5**
Minumum	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**
Maximum	**36**	**18**	**4.5**	**9**	**9**	**18**	**0.75**	**18**	**3**	**36**
Interquartile Range	**5.375**	**2.5**	**2.75**	**4.25**	**3.75**	**5.375**	**0.25**	**3.625**	**0.8125**	**7**

The numbers in the columns are wait times in months organized by site and procedure. Each column is a heat map, dark red is a higher number.

Figure III: Box and Whiskers Plot of Waitlist Time



The box and whisker plot showcases the distribution of waitlist times by procedures across sites. The gray boxes range from 25th to 75th %ile, while the whiskers range from 5th to 95th %ile.

In the comments section of the survey respondents stated that lack of theater space and hospital beds for post operative patients were notable barriers to delivering surgical care. In addition waitlists were not limited to the above procedures as providers had the opportunity to add additional responses. They listed a diverse group of cases with varied acuity, complexity and wait times.

Table 3: Waitlist for additional procedures not listed in survey organized by orthopedic pathology.

Sub Specialty	Wait Time (Months)	Number of Patients	Site
Orthopedic			
Syndactyly	18	50.00	CHU Pediatrique Charles de Gaulle
Chronic Bone Infection (Osteomyelitis)	9.00	120.00	CHU Pediatrique Charles de Gaulle
Congenital limb deformities	2.00	4.00	Lagos University Teaching Hospital
Obstetric brachial plexus injury	2.00	4.00	Lagos University Teaching Hospital
Release of Syndactyly	0.25	1.00	National Orthopaedic Hospital Enugu
Corrective Osteotomy	0.25	12.00	National Orthopaedic Hospital Enugu
Group Statistics			
Median	2	4.00	
Minimum	0.25	1.00	
Maximum	18	120.00	
Interquartile Range	6.56	36.5	

Table 4: Waitlist for additional procedures not listed in survey organized by general pediatric surgery pathology.

Subspecialty			
General	**Wait Time (Months)**	**Number of Patients**	**Site**
Omphalocele repairs	36	30	Bugando Hospital
Bladder Exstrophy (Second time repair)	18	60	CHU Pediatrique Charles de Gaulle
Sistrunk Procedure	2	10	Arthur Davison Children's Hospital
Male Circumcision	2	200	Arthur Davison Children's Hospital
Rectal and Leveling Biopsy	2	5	Bugando Hospital
Esophageal Stenosis Dilation	2	80	CHU Pediatrique Charles de Gaulle
Skin Graft	0.75	8	Arthur Davison Children's Hospital
Umbilical Hernia Repair	0.75	4	Bugando Hospital
Colostomy Creation	0.75	5	Bugando Hospital
Wide Local Excision	0.75	10	Muhimbili National

			Hospital
Kasai	0.75	4	Muhimbili National Hospital
Varicocelectomy	0.25	1	National Hospital Abuja
Group Statistics			
Median	2	25	
Minimum	0.25	1	
Maximum	36	60	
Interquartile Range	3.13	47.5	

Discussion

This cross-sectional study assessed the pediatric surgical backlog in LMICs using self reported provider surveys from February to June of 2021. Pediatric surgical providers at 15 different sites in 8 countries in Sub-Saharan Africa and Ecuador completed the survey. To our knowledge, this is one of the first studies to characterize pediatric surgical waitlists by procedure in LMICs, using a multisite self reported survey.

The overall median wait time was 2 months, with a median waitlist length of 90 patients. Given the breadth of surgical delivery systems included, we found a wide range of waitlist length (8-2,500 cumulative patients for all procedures) and wait time (0.25-36 months). The CHU Pediatric Charles de Gaule facility in Burkina Faso reported the largest number of patients on their waitlist. Meanwhile, Kamuzu Central Hospital Lilongwe in Malawi held the longest wait time with a median overall duration of 36 months, and a waitlist of 90 patients. In Lilongwe, providers stopped scheduling inguinal hernias and orchiopexies since they do not have enough OR space to do them. On rare occasions, they might call a patient with an elective hernia or orchiopexy if there are not enough index cases waiting on the ward. Similar reports have emerged from other sites in the past, especially noting that elective cases are often neglected as emergency cases take priority. Given the infrequency with which these elective cases are performed, 36 months was a conservative estimate based on wait times at other facilities.

Surgical procedures with the longest wait times included hypospadias (mean of 4.5 months) and anoplasty procedures (median 4.5 months). This finding corroborated a previous scoping review on delays in congenital anomaly repairs in Sub-Saharan Africa, which reported substantial backlogs in hypospadias repair (59,180 cases over 6 countries) and anorectal malformations (2,001 cases over 5 countries).[13] Multiple other single-site studies have demonstrated the delay in repairs of congenital anomalies in Kenya, Somaliland, Uganda, and Nigeria, with its associated preventable disease burden.[8], [14]–[18] For surgical volume, hernia repair, hypospadias repair and orchiopexy were surgical procedures with the largest backlogs. This delay is unsurprising, given the relatively non-acute nature of these anatomical anomalies that confer morbidity and much less frequent mortality. This of course should not trivialize the disability risk from incarcerated hernia which has a very real mortality likelihood in young patients. From experience, we see desperate families seek care from unqualified surgical providers which can lead to attendant complications.

Of note, De los Valles Hospital in Ecuador is a private, for-profit, facility located in an upper middle income country. It had both the shortest waitlist and wait time for all elective procedures. Since the other hospitals in the study were either public or mission hospitals in Sub-Saharan Africa, de los Valles provides a stark point of contrast. We also stratified wait time by lower, lower-middle (Nigeria and Tanzania), and upper-middle income (Ecuador) country status but there was no difference in wait time between low- and lower-middle income countries. In our study, patients in low- and lower- middle income countries who utilized facilities that traditionally serve low income patients struggled with prompt access to surgery during the pandemic while patients at a private hospital in an upper middle income country did not suffer such a significant delay in care.

Even though emergent cases are generally prioritized over elective cases, semi-urgent procedures such as ventriculoperitoneal shunt required a substantial wait time with a median wait of 2 weeks. Tumor resections also had a considerable delay, with wait time ranging from 3 weeks to 3 months. Kasai procedures for biliary atresia were also reported, and the timing of surgery for this condition is directly related to survival. Backlog in these time-sensitive procedures are concerning and suggest that the scarcity of pediatric surgical capacity in LMICs also affects more acute surgical conditions leading to excess preventable morbidity and mortality.

Our survey predominantly included surgical congenital anomalies. Nevertheless, stakeholders are tasked with taking care of elective congenital anomalies, urgent, and emergent procedures simultaneously. It is challenging to meet the needs of the population with this system, which is in place in most LMICs. A recent prospective cohort study spanning 19 Sub-Saharan African (SSA) countries demonstrated that mortality from pediatric surgical disease is significantly higher in SSA than HIC: gastroschisis (75.5% vs 2.0%), anorectal malformation (11.2% vs 2.9%), intussusception (9.4% vs 0.2%), appendicitis (0.4% vs 0.0%) and inguinal hernia (0.2% vs 0.0%), respectively.[19] Our findings suggest that delay in surgical treatment is likely a contributing factor and that COVID-19 exacerbated these delays.

In light of the recent COVID-19 pandemic, worldwide national lockdowns greatly diminished surgical volume in both HICs and LMICs.[1] LMICs have a reduced capacity to consolidate resources to rebound from the setback, compounding already extensive waitlists. A survey of 74 Nigerian pediatric surgeons on the impact of COVID-19 pandemic reported that 92% of centers suspended elective surgeries while emergency surgeries were offered but cases were reduced by 31%.[20] In a recent interrupted time series analysis (ITSA) there was a decrease in surgical volume without evidence of sustained recovery across multiple LMIC hospitals. The ITSA demonstrated the persistent effects of the pandemic and provided evidence that the collateral damage of the pandemic on health services extended to children's surgery. [21]

The surgical backlog demonstrated in this study fits into the Three Delays Model. This model characterizes delays in preventable maternal mortality associated with: 1) deciding to seek care, 2) accessing a quality healthcare facility, and 3) obtaining appropriate care.[24] The model has been subsequently applied to neonatal mortality and delays in pediatric surgery in resource limited settings.[25], [26] COVID-19 and limited financial resources likely reduced the number of patients who chose to seek care and inadequate pediatric surgical capacity led to long wait times and waitlists for those patients who did present to a pediatric surgeon. Although all three

types of delays likely affect children with surgical conditions our study focuses on the third delay: obtaining appropriate care. Yet patients who were documented in waitlists at these sites only account for those who successfully made contact with the healthcare facility. Not captured were patients who never accessed a pediatric surgeon, perhaps for a variety of reasons: prohibitive cost, transportation barriers, and COVID-19 restrictions to name just a few. Given the multilevel barriers preventing a child from receiving much needed care in low-resource settings no single study can completely characterize the surgical backlog.

A major strength of the study is the inclusion of multiple sites over a broad array of countries straddling two continents, enhancing the generalizability of our findings. The disease-specific detail of the backlogs also allows for the examination of backlog at a more granular level, enabling some distinction between purely elective and semi-elective procedures. Study limitations include the cross-sectional design, such that only a single time-point was captured without analysis of trends over time. This is especially relevant during the COVID-19 pandemic with its associated escalating surgical delays.

In the future we could repeat the survey in the post-COVID period and compare backlog volumes. For most centers the likelihood is that there would be no catching up. The recent COVID surg study estimated 45 weeks to clear the backlog if there was a 20% increase in activity, and most LMIC centers would not have the resources for this scale up. [1] Furthermore, this was a self-reported survey from surgical providers who provided estimates for wait times and the potential for recall bias exists.

Despite this study's limitations it not only highlights the importance of tracking surgical backlogs but also demonstrates the investment needed in the healthcare workforce and infrastructure. Some sites only have one pediatric surgeon and the OR cannot reach 100% utilization without investment in other cadres of the health workforce. The longest wait time (Lilongwe) reported difficulty performing elective cases due to lack of OR space. This is even despite recent investment in upscaling pediatric theater space from KidsOR. From anecdotal experience late presentation generally leads to excess resource utilization, morbidity, and mortality but we have not measured how delays may render some conditions inoperable, or much more challenging and expensive to treat.

Strides have been made to improve surgical data collection in LMICs. KidsOR has collaborated with sites to collect perioperative data. Yet currently, there is no record of who is waiting for surgery. The moral insult that providers suffer when they lack the resources to provide care to children they know need help also injures those tasked with the enormous responsibility of caring for patients in under-resourced environments. In order to improve humanitarian outreach and more importantly buoy the efforts of local champions then stakeholders must track cases and backlogs. Data should direct global interventions for these vulnerable and neglected patients and surgical waitlists are critical to prevent ongoing suffering.

Conclusion

Lengthy surgical wait times affect surgical access in LMICs. COVID-19 caused surgical delays around the world making surgical backlogs even worse in many locations. Given the high burden

of children's surgery in low resource settings an assessment of backlogs for children's surgery during the pandemic was necessary to help determine a contextually appropriate response to the pandemic. The results of our multisite self reported study revealed significant delays for elective, urgent and emergent cases across Sub-Saharan Africa at both governmental and private hospitals during the pandemic. For all elective surgery, three sites listed surgical backlogs in the 1000s and three sites had a wait time more than 1.5 years. With these results in mind stakeholders and advocates should scale the already limited surgical resources in LMICs, develop strategies for future pandemics, and determine efficient ways to maintain and monitor robust data driven waitlists.

Bibliography

[1] COVIDSurg Collaborative, "Elective surgery cancellations due to the COVID-19 pandemic: global predictive modeling to inform surgical recovery plans: Elective surgery during the SARS-CoV-2 pandemic," *Br. J. Surg.*, Jun. 2020, doi: 10.1002/bjs.11746.

[2] COVIDSurg Collaborative *et al.*, "Global guidance for surgical care during the COVID-19 pandemic," *Br. J. Surg.*, vol. 107, no. 9, pp. 1097–1103, Jul. 2020, doi: 10.1002/bjs.11646.

[3] GlobalSurg Collaborative, "Mortality of emergency abdominal surgery in high-, middle- and low-income countries," *Br. J. Surg.*, vol. 103, no. 8, pp. 971–988, Jul. 2016, doi: 10.1002/bjs.10151.

[4] International Surgical Outcomes Study group, "Global patient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries," *Br. J. Anaesth.*, vol. 117, no. 5, pp. 601–609, Oct. 2016, doi: 10.1093/bja/aew316.

[5] B. M. Biccard *et al.*, "Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study," *The Lancet*, vol. 391, no. 10130, pp. 1589–1598, Apr. 2018, doi: 10.1016/S0140-6736(18)30001-1.

[6] S. Bickler *et al.*, "Key Concepts for Estimating the Burden of Surgical Conditions and the Unmet Need for Surgical Care," *World J. Surg.*, vol. 34, no. 3, pp. 374–380, Mar. 2010, doi: 10.1007/s00268-009-0261-6.

[7] D. Poenaru, D. Ozgediz, and R. A. Gosselin, "Burden, need, or backlog: A call for improved metrics for the global burden of surgical disease," *Int. J. Surg.*, vol. 12, no. 5, pp. 483–486, May 2014, doi: 10.1016/j.ijsu.2014.01.021.

[8] S. J. Ullrich *et al.*, "Burden and Outcomes of Neonatal Surgery in Uganda: Results of a Five-Year Prospective Study," *J. Surg. Res.*, vol. 246, pp. 93–99, Feb. 2020, doi: 10.1016/j.jss.2019.08.015.

[9] J. Wang *et al.*, "Clearing the surgical backlog caused by COVID-19 in Ontario: a time series modelling study," *Can. Med. Assoc. J.*, vol. 192, no. 44, pp. E1347–E1356, Nov. 2020, doi: 10.1503/cmaj.201521.

[10] R. Badrinath, N. Kakembo, P. Kisa, M. Langer, D. Ozgediz, and J. Sekabira, "Outcomes and unmet need for neonatal surgery in a resource-limited environment: Estimates of global health disparities from Kampala, Uganda," *J. Pediatr. Surg.*, vol. 49, no. 12, pp. 1825–1830, Dec. 2014, doi: 10.1016/j.jpedsurg.2014.09.031.

[11] S. Cairo *et al.*, "Disparity in access and outcomes for emergency neonatal surgery: intestinal atresia in Kampala, Uganda," *Pediatr. Surg. Int.*, vol. 33, no. 8, pp. 907–915, Aug. 2017, doi: 10.1007/s00383-017-4120-5.

[12] R. G. Maine *et al.*, "Prevalence of Untreated Surgical Conditions in Rural Rwanda: A Population-Based Cross-sectional Study in Burera District," *JAMA Surg.*, vol. 152, no. 12, p. e174013, Dec. 2017, doi: 10.1001/jamasurg.2017.4013.

[13] Y. Yousef, A. Lee, F. Ayele, and D. Poenaru, "Delayed access to care and unmet burden of pediatric surgical disease in resource-constrained African countries," *J. Pediatr. Surg.*, vol. 54, no. 4, pp. 845–853, Apr. 2019, doi: 10.1016/j.jpedsurg.2018.06.018.

[14] V. K. Wu and D. Poenaru, "Burden of Surgically Correctable Disabilities Among Children in the

Dadaab Refugee Camp," *World J. Surg.*, vol. 37, no. 7, pp. 1536–1543, Jul. 2013, doi: 10.1007/s00268-012-1899-z.
[15] D. Poenaru, J. Pemberton, and B. H. Cameron, "The burden of waiting: DALYs accrued from delayed access to pediatric surgery in Kenya and Canada," *J. Pediatr. Surg.*, vol. 50, no. 5, pp. 765–770, May 2015, doi: 10.1016/j.jpedsurg.2015.02.033.
[16] R. Ugwu and P. Okoro, "Pattern, outcome and challenges of neonatal surgical cases in a tertiary teaching hospital," *Afr. J. Paediatr. Surg.*, vol. 10, no. 3, p. 226, 2013, doi: 10.4103/0189-6725.120886.
[17] the Global Initiative for Children's Surgery *et al.*, "Waiting Too Long: The Contribution of Delayed Surgical Access to Pediatric Disease Burden in Somaliland," *World J. Surg.*, vol. 44, no. 3, pp. 656–664, Mar. 2020, doi: 10.1007/s00268-019-05239-w.
[18] D. F. Grabski *et al.*, "Burden of emergency pediatric surgical procedures on surgical capacity in Uganda: a new metric for health system performance," *Surgery*, vol. 167, no. 3, pp. 668–674, Mar. 2020, doi: 10.1016/j.surg.2019.12.002.
[19] PaedSurg Africa Research Collaboration, "Paediatric surgical outcomes in sub-Saharan Africa: a multicentre, international, prospective cohort study," *BMJ Glob. Health*, vol. 6, no. 9, p. e004406, Sep. 2021, doi: 10.1136/bmjgh-2020-004406.
[20] I. O. Ogundele, F. M. Alakaloko, C. C. Nwokoro, and E. A. Ameh, "Early impact of COVID-19 pandemic on paediatric surgical practice in Nigeria: a national survey of paediatric surgeons," *BMJ Paediatr. Open*, vol. 4, no. 1, p. e000732, Sep. 2020, doi: 10.1136/bmjpo-2020-000732.
[21] Park, Paul *et al.*, "Impact of the COVID-19 Pandemic on Pediatric Surgical Volume in four Low- and Middle-Income Country Hospitals: Insights from an Interrupted Time Series Analysis," *World J. Surg.*, vol. In press.
[22] "Considering the impact of COVID-19 on children." https://www.who.int/europe/activities/considering-the-impact-of-covid-19-on-children (accessed Jul. 02, 2022).
[23] L. A. de Araújo, C. F. Veloso, M. de C. Souza, J. M. C. de Azevedo, and G. Tarro, "The potential impact of the COVID-19 pandemic on child growth and development: a systematic review," *J. Pediatr. (Rio J.)*, vol. 97, no. 4, pp. 369–377, Jul. 2021, doi: 10.1016/j.jped.2020.08.008.
[24] S. Thaddeus and D. Maine, "Too far to walk: Maternal mortality in context," *Soc. Sci. Med.*, vol. 38, no. 8, pp. 1091–1110, Apr. 1994, doi: 10.1016/0277-9536(94)90226-7.
[25] N. M. Ruzgar *et al.*, "The Three Delays' Impact in Uganda: The Disease Burden and Operative Backlog at a New Pediatric Surgery Outpatient Clinic of a Tertiary Center," *Pediatrics*, vol. 146, no. 1 MeetingAbstract, p. 278, Jul. 2020, doi: 10.1542/peds.146.1_MeetingAbstract.278.
[26] E. Wilmot, M. Yotebieng, A. Norris, and F. Ngabo, "Missed Opportunities in Neonatal Deaths in Rwanda: Applying the Three Delays Model in a Cross-Sectional Analysis of Neonatal Death," *Matern. Child Health J.*, vol. 21, no. 5, pp. 1121–1129, May 2017, doi: 10.1007/s10995-016-2210-y.
[27] N. Kakembo *et al.*, "Barriers to Pediatric Surgical Care in Low-Income Countries: The Three Delays' Impact in Uganda," *J. Surg. Res.*, vol. 242, pp. 193–199, Oct. 2019, doi: 10.1016/j.jss.2019.03.058.
[28] G. S. Philipo *et al.*, "A Journey Undertaken by Families to Access General Surgical Care for their Children at Muhimbili National Hospital, Tanzania; Prospective Observational Cohort Study," *World J. Surg.*, vol. 46, no. 7, pp. 1643–1659, Jul. 2022, doi: 10.1007/s00268-022-06530-z.
[29] V. Madhuri, R. J. Stewart, and K. Lakhoo, "Training of children's surgical teams at district level in low- and middle-income countries (LMIC): from concept to reality—a south to south initiative," *Int. J. Surg. Glob. Health*, vol. 2, no. 3, pp. e08–e08, Oct. 2019, doi: 10.1097/GH9.0000000000000008.