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Access to pediatric surgery delivered by general surgeons and anesthesia providers in Uganda: Results from 2 rural regional hospitals

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ABSTRACT

Background: Significant limitations in pediatric surgical capacity exist in low- and middle-income countries, especially in rural regions. Recent global children's surgical guidelines suggest training and support of general surgeons in rural regional hospitals as an effective approach to increasing pediatric surgical capacity.

Methods: Two years of a prospective clinical database of children's surgery admissions at 2 regional referral hospitals in Uganda were reviewed. Primary outcomes included case volume and clinical outcomes of children at each hospital. Additionally, the disability-adjusted life-years averted by delivery of pediatric surgical services at these hospitals were calculated. Using a value of statistical life calculation, we also estimated the economic benefit of the pediatric surgical care currently being delivered.

Results: From 2016 to 2019, more than 300 surgical procedures were performed at each hospital per year. The majority of cases were standard general surgery cases including hernia repairs and intussusception as well as procedures for surgical infections and trauma. In-hospital mortality was 2.4% in Soroti and 1% in Lacor. Pediatric surgical capacity at these hospitals resulted in over 12,400 disability-adjusted life-years averted/year. This represents an estimated economic benefit of 10.2 million US dollars/year to the Ugandan society.

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Conclusion: This investigation demonstrates that lifesaving pediatric procedures are safely performed by general surgeons in Uganda. General surgeons who perform pediatric surgery significantly increase surgical access to rural regions of the country and add a large economic benefit to Ugandan society. Overall, the results of the study support increasing pediatric surgical capacity in rural areas of low- and middle-income countries through support and training of general surgeons and anesthesia providers.

Introduction

Although the significant economic benefit of increasing surgical capacity in low- and middle-income countries (LMICs) has been highlighted,[1,2] investment in children's surgical capacity in LMICs continues to be neglected.[3,4] Recent estimates suggest that 1.7 billion children lack access to safe surgical care around the world, largely in LMICs.[5] Significant limitations in pediatric surgical access have been specifically demonstrated in East Africa.[6–13]

In Uganda, the setting of this investigation, the relative lack of human resources, perioperative specialty training programs, and operative resources have all limited surgical access for children.[14,15] There is also an equity gap in access between children living in rural and urban areas in Uganda.[16] At the time of this investigation, there were 6 board-certified pediatric surgeons and 5 fellows for a country of 20 million children. Recommendations by the American Pediatric Surgery Association include an appropriate ratio of 1 pediatric surgeon for every 100,000 children.[17] Given this requirement, Uganda would require an additional 190 pediatric surgeons. The board-certified pediatric surgeons in Uganda currently work in the capital city of Kampala and the major referral hospital in western Uganda, Mbarara. The 2 large referral hospitals in northern Uganda (Lacor in Gulu) and Eastern Uganda (Soroti) do not have board-certified pediatric surgeons at their hospital systems. Additionally, the hospitals are 291 km and 334 km away from Kampala, respectively. With road conditions in Uganda, this translates to a 6- to 10-hour travel time between the cities.

Recent strategies to increase surgical capacity for children living in Uganda have included equipping dedicated pediatric operating rooms, developing a funded fellowship training program, and the integration of international academic partnerships and short-term rural outreach as well as pediatric surgical education for frontline providers.[18–22] Additionally, recent international guidelines for children's surgery recommend educational interventions and task-sharing initiatives with general surgeons and physicians in rural hospitals who can perform select pediatric elective surgical procedures as well as emergency life-saving operations.[23,24]

A national children's surgery stakeholders' meeting was held in Kampala, Uganda in 2015.[20] At the meeting, a major area of focus was to increase pediatric surgical capacity at regional referral hospitals. Both Soroti Regional Referral Hospital and St Mary's Lacor Regional Referral Hospital had representatives at the meeting. Each hospital had general surgeons with long-standing relationships with both national and international children's surgery teams.[20] Both hospitals also represented tertiary care facilities and the major referral hospitals for their respective regions. At the meeting, stakeholders agreed to prioritize partnerships with international stakeholders and rural outreach to these hospitals to increase regional pediatric surgical capacity.

After the meeting, a prospective clinical pediatric surgical database developed at Mulago National Referral Hospital was implemented at both sites in 2016 to measure the case volume as well as clinical outcomes.[25] This investigation uses these 2 databases to describe the impact on pediatric surgical access in Uganda from these 2 rural regional referral hospitals with general surgery teams. We hypothesize that general surgeons can deliver safe, regional care to children as well as have a meaningful impact on the overall burden of pediatric surgical disease in the country.

Methods

Study setting

The prospective clinical databases of children treated at Soroti and St Mary's Lacor Regional Referral Hospitals were evaluated. Soroti began data collection in January 2016 and continued through June 2018. Lacor began data collection from June 2016 to September 2016 and again from September 2017 to June 2019. The full data sets from each hospital were included in our analysis. Soroti's data collection period (2.6 years of data collection) was time averaged to Lacor's period (2 years of data collection) to allow for comparison (tables and figures represent the 2-year normalized data from Soroti and the full data set from Lacor). All children younger than 13 years of age who were treated by the general surgery team were included in analysis regardless of presenting pathology, operation, or clinical outcome. Patient data were excluded from analysis if there were insufficient clinical, operative, or outcome details during their admission to allow for appropriate clinical description.

Study outcomes and analysis

The primary outcome of this investigation was the case volume at each hospital. Secondary outcomes were in-hospital and postsurgical mortality. To quantify the averted burden of disease by pediatric surgery at the 2 regional referral hospitals, the averted disability-adjusted life-years (DALYs) were calculated from operative treatment of common pediatric surgical disease as well as nonoperative treatment of trauma performed by the surgery team. We used a value of statistical life approach to establish the corresponding economic benefit of pediatric surgery delivery at the 2 respective hospitals.[26]

For the descriptive analysis of case volume, mean and standard deviation are reported for normally distributed variables, whereas median and interquartile range are reported for nonparametric data. Statistical significance was calculated using the Student's t test, the Wilcoxon rank sum test, and the χ^2 test as appropriate. All hypothesis tests were considered 2-sided. Data from each site were collected and stored using Microsoft Access 2016 (Redmond, WA). Data analysis was performed using SPSS version 25 (IBM, New York). The heatmap of Ugandan health districts that referred patients to each respective hospital was produced using the Datawrapper software package (https://www.datawrapper.de/).

DALYs averted/year were calculated using the Global Burden of Disease (GBD) methodology as described in a previous publication of met and unmet pediatric surgical need in Uganda.[27,28] DALYs averted/year were calculated for each site separately based on the operative incidence or treatment-incidence for nonoperative trauma of patients who were discharged. Diseases that represented at least 1% of the total disease perveance in the database were

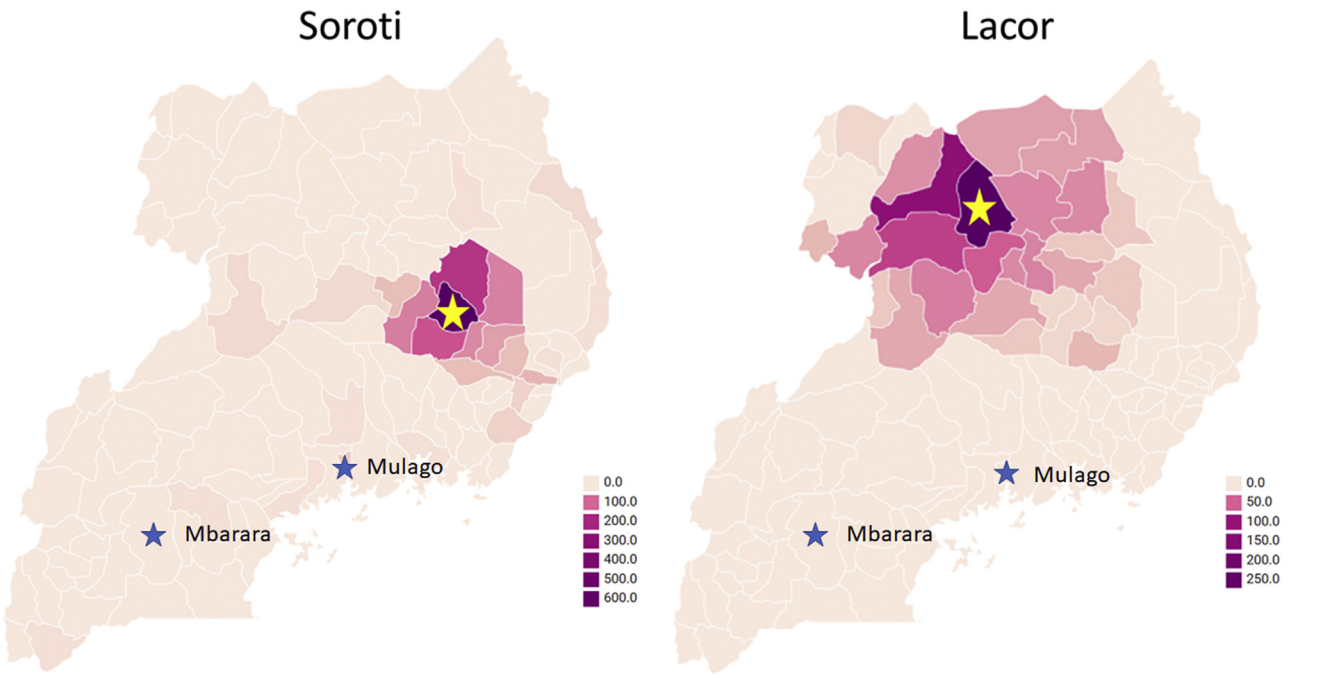

Fig 1. Heatmap of Health Districts in Uganda. Color density represents the number of children presenting to each respective hospital form surrounding health districts. The yellow stars represent the sites of each hospital.

included in the calculation. We did not perform a time or age discount on the DALYs averted because this is no longer recommended by the WHO Guidelines.[29] The disability weights (DW) were derived from published literature and, when available, from DW derived from East African pediatric-specific data.[27,28,30–39] The life expectancy in Uganda at the time of this study was 63 years.[40] Using the methodology described in the Disease Control Priorities 3, our group previously calculated the value of statistical life in Uganda to be 827.32 USD with an income elasticity of 1.5.[41] The economic benefit of pediatric surgery at Soroti and Lacor was calculated by multiplying the DALYs averted/year by the value of statistical life in Uganda.

Ethical approval

The study was approved by the Institutional Review Board at Mulago Hospital in Kampala, Uganda (Protocol #MREC: 464) and at Yale University School of Medicine (Protocol #1605017844). Ethics approval for the investigation was also obtained at Soroti and Lacor at the commencement of the study.

Results

There were 2,028 children treated at the 2 hospitals over the study period. Data from 64 patients were removed due to insufficient details at clinical presentation or of surgical outcome. In total, 1,964 patients were analyzed, 1,231 (62.7%) from Soroti and 733 (37.3%) from Lacor. The median age of patients were 3.0 years (IQR 1.1–6.5), and 576 of the patients were female (29.3%). Children presented from a total of 60 health districts, 25 at Soroti and 35 at Lacor. The heatmap of health districts that referred patients to each hospital demonstrated both sites had regionally specific referral patterns (Fig 1).

The distribution of surgical pathology at both hospitals is reported in Table I. The most common category presenting to either site was standard general pediatric surgery pathology including inguinal hernias (14.5% of total case volume at Soroti, 11.5% of total case volume at Lacor), hydroceles, umbilical hernias, and intussusception. There were similar relative distributions of trauma and burns at each hospital, with 21.4% of surgical presentation at Soroti ($n = 196$) and 17.3% at Lacor ($n = 127$). There were also statistical differences between presenting pathology each hospital. At Soroti, 31.8% of patients ($n = 291$) presented with surgical infections (infectious pathology requiring surgical intervention), whereas at Lacor it was 13.8% ($n = 101$) ($P < .0001$). Conversely, Lacor had a higher distribution of subspecialty pathology presentations (pathology often treated by urology, ENT, orthopedic, or neurosurgery) than Soroti (16.2% [$n = 119$] vs 7.1% [$n = 65$], $P < .0001$). Interestingly, congenital anomalies made up 13.2% of total pathology at Soroti ($n = 121$) and 17.7% at Lacor ($n = 130$) ($P = .0003$). Compared to the other surgical pathology categories, oncology cases were minimal at both hospitals (2.3% at Soroti [$n = 21$], 5.9% at Lacor [$n = 43$]).

The distribution of operative volume is reported in Table II. The overall operative rate in each database was 86% at both hospitals. The most common operations at Soroti were procedures for abscesses ($n = 220$), inguinal hernias ($n = 130$), and wound infections ($n = 43$), as well as orthopedic trauma ($n = 36$) and soft tissue injury repairs ($n = 36$). At Lacor, the most common procedures were inguinal hernia repairs ($n = 83$), abscesses ($n = 68$), and hydroceles ($n = 59$) (Fig 2). At Soroti, approximately 40 procedures were completed for anorectal malformations (ARM), but the majority were diverting colostomy with 12 (29.6%) definitive posterior sagittal anorectoplasty repairs. Similarly, of the 41 cases for ARM at Lacor, 18 (43.9%) were definitive repairs. Hirschsprung's disease cases had a similar management trend; the majority of procedures were colostomy diversions. The overall and postoperative in-hospital mortality at each site was 2.4% and 1% at Soroti and Lacor, respectively. The highest in-hospital mortality at both hospitals was attributed to congenital anomalies (7.7% at Soroti and 5.6% at Lacor). The majority of mortalities were attributed to ARM (6.9% mortality at Soroti and 2.3% at Lacor), Hirschsprung's disease (8% mortality at Soroti), and gastroschisis (100% at Lacor). Additionally, intussusception had a 23.5% mortality at Soroti. All mortalities from the database are detailed in Table III.

Table I
Distribution of most frequently presenting surgical pathology and associated overall in-hospital mortality at Soroti and Lacor Regional Referral Hospitals

Surgical pathology	Soroti		Lacor		Total		P values
	Total patients (% total)	Overall mortality	Total patients (% total)	Overall mortality	Total patients (% total)	Overall mortality	Pathology
General surgical pathology	226 (24.6%)	6 (2.7%)	219 (29.8%)	0 (0%)	444 (26.9%)	6 (1.4%)	<.0001
Inguinal hernias	133 (14.5%)	0 (0%)	84 (11.5%)	0 (0%)	217 (13.2%)	0 (0%)	
Hydrocele	7 (0.7%)	0 (0%)	60 (8.2%)	0 (0%)	67 (4%)	0 (0%)	
Umbilical hernias	22 (2.4%)	0 (0%)	11 (1.5%)	0 (0%)	33 (2%)	0 (0%)	
Intussusception	17 (1.9%)	4 (23.5%)	16 (2.2%)	0 (0%)	33 (2%)	4 (12.1%)	
Postsurgical complications	7 (0.7%)	0 (0%)	11 (1.5%)	0 (0%)	18 (1.1%)	0 (0%)	
Small bowel obstruction	12 (1.3%)	1 (8.3%)	5 (0.7%)	0 (0%)	17 (1%)	1 (5.8%)	
Pyloric stenosis	4 (0.4%)	1 (25%)	6 (0.8%)	0 (0%)	10 (0.6%)	1 (10%)	
Infection	291 (31.8%)	2 (0.7%)	101 (13.8%)	0 (0%)	392 (23.8%)	2 (0.5%)	<.0001
Abscess/cellulitis	230 (25.1%)	1 (0.3%)	72 (9.8%)	0 (0%)	302 (18.3%)	1 (0.3%)	
Wound infection	53 (5.8%)	0 (0%)	11 (1.5%)	0 (0%)	64 (3.9%)	0 (0%)	
Appendicitis	1 (0.2%)	0 (0%)	8 (1.1%)	0 (0%)	9 (0.6%)	0 (0%)	
Trauma/burns	196 (21.4%)	5 (2.6%)	127 (17.3%)	0 (0%)	323 (19.6%)	5 (1.5%)	<.0001
Orthopedic trauma	57 (6.3%)	0 (0%)	46 (6.3%)	0 (0%)	103 (6.3%)	0 (0%)	
Laceration/soft tissue injury	41 (4.5%)	1 (2.4%)	9 (1.2%)	0 (0%)	50 (3%)	1 (2%)	
Burns/burn complication	19 (2%)	1 (5.2%)	31 (4.2%)	0 (0%)	50 (3%)	1 (2%)	
Blunt abdominal trauma	24 (2.6%)	1 (4.1%)	10 (1.4%)	0 (0%)	34 (2.1%)	1 (2.9%)	
Trauma NOS	16 (1.7%)	1 (6.3%)	16 (2.2%)	0 (0%)	32 (1.9%)	1 (3.1%)	
Head injury	16 (1.7%)	1 (6.3%)	6 (0.8%)	0 (0%)	22 (1.3%)	1 (4.5%)	
Congenital anomaly	117 (12.7%)	9 (7.7%)	124 (16.9%)	7 (5.6%)	251 (15.2%)	16 (6.3%)	.0003
Anorectal malformation	43 (4.7%)	3 (6.9%)	43 (5.9%)	1 (2.3%)	86 (5.2%)	4 (4.6%)	
Hirschsprung's disease	50 (5.4%)	4 (8%)	24 (3.3%)	0 (0%)	74 (4.5%)	4 (5.4%)	
Hypospadias	5 (0.6%)	0 (0%)	20 (2.7%)	0 (0%)	25 (1.5%)	0 (0%)	
Undescended testis	10 (1.1%)	0 (0%)	14 (1.9%)	0 (0%)	24 (1.4%)	0 (0%)	
Gastroschisis	4 (0.4%)	2 (50%)	4 (0.5%)	4 (100%)	8 (0.5%)	6 (75%)	
Oncology/masses	21 (2.3%)	0 (0%)	43 (5.9%)	0 (0%)	64 (3.9%)	0 (0%)	.0026
Cystic hygroma, lymphatic malformation	2 (0.2%)	0 (0%)	15 (2%)	0 (0%)	17 (1%)	0 (0%)	
Soft tissue mass NOS	4 (0.4%)	0 (0%)	12 (1.6%)	0 (0%)	16 (1%)	0 (0%)	
Abdominal malignancy	4 (0.4%)	0 (0%)	4 (0.5%)	0 (0%)	8 (0.5%)	0 (0%)	
Subspecialty	65 (7.1%)	0 (0%)	119 (16.2%)	0 (0%)	184 (11.2%)	0 (0%)	<.0001
Urology	34 (3.7%)	0 (0%)	70 (9.5%)	0 (0%)	104 (6.3%)	0 (0%)	
ENT	6 (0.6%)	0 (0%)	32 (4.4%)	0 (0%)	38 (2.3%)	0 (0%)	
Orthopedic surgery	19 (2.1%)	0 (0%)	15 (2%)	0 (0%)	34 (2.1%)	0 (0%)	
Neurosurgery	6 (0.6%)	0 (0%)	2 (0.3%)	0 (0%)	8 (0.5%)	0 (0%)	
Total	916 (100%)	22 (2.4%)	733 (100%)	7 (1%)	1649 (100%)	29 (1.7%)	<.0001

Total number of children presenting with each respective pathology are presented first with the percentage representing the fraction of total patients presenting to each hospital. Statistical analysis represents the comparison between incidence of surgical pathology between Soroti and Lacor hospitals. Statistical tests (*P* value) represent either Student's *t* test, Wilcoxon rank sum test, or chi-squared test.
ENT, otolaryngology; *NOS*, not otherwise specified.

A total of 7,020.6 DALYs were averted per year at Soroti by pediatric surgical care (Supplemental Table S1), and 5,388.9 DALYs were averted at Lacor (Supplemental Table S2) by pediatric surgical care delivery. At both sites, DALYs averted tracked with surgical pathology and operative volume. At Soroti, 1,895.3 DALYs were averted by repairing inguinal hernias, 1,096.7 DALYs were averted by treating surgical infections, and 879.5 DALYs were averted by operative and nonoperative trauma care. Similarly, at Lacor 1,207.8 DALYs were averted by inguinal hernia repairs, 981.3 DALYs were averted per year by treating trauma cases, and 480.9 DALYs were averted per year by treating surgical infections. The economic benefit of surgical care delivered at Soroti was 5.8 million USD/year, and at Lacor it was 4.5 million USD/year. Over the 5-year period since the stakeholders' meeting in 2015, the combined economic benefit of pediatric surgical care delivered at these 2 regional hospitals was 51.3 million USD.

Discussion

Surgical access for children in rural Uganda, as in other LMICs, continues to be a major child health challenge. Long and expensive travel times for families make referrals to the national referral hospital impractical, leading to even greater discrepancies in surgical access between children living in rural and urban communities.[16] As such, access to pediatric surgery is either not available or delivered by general surgeons in regional referral hospitals. Although the number of fellowship-trained pediatric surgeons and pediatric anesthesiologists is slowly increasing, attention must still be directed at supporting general surgeons and their perioperative teams to deliver pediatric surgical care, through ongoing education, support, and outreach.[20,24]

We report the delivery of pediatric surgical care at 2 regional hospitals by general surgeons and their associated perioperative teams. Our data demonstrate that the general surgery teams at Soroti and Lacor are performing approximately 300 cases/year of elective and emergency pediatric surgery. The majority of cases address basic standard general surgical pathology, including hernia repairs and exploratory laparotomies for intussusception. Additionally, between 30% and 50% of the procedures at each hospital are urgent or emergency procedures for surgical infections or trauma, which is consistent with data from pediatric surgery operative log reviews in sub-Saharan Africa.[42–44] Importantly, the general surgery teams are performing safe surgery at both regional hospitals, leading to an increase in regionally specific pediatric surgical access in the country. The increase in access has led to significant economic benefits to the Uganda society over the last 5 years.

Pediatric surgery performed by trained general surgeons is safe and effective

The postoperative and overall inpatient mortality rates at both hospitals were low for the majority of surgical pathology.

Table II
Distribution of most frequent surgical procedures with overall operative rate at Soroti and Lacor Regional Referral Hospitals

Surgical pathology	Soroti	Lacor	Total	P value
General Surgical Pathology	210 (93%)	208 (94.8%)	418 (93.9%)	<.0001
Inguinal hernias	130 (97.8%)	83 (98.8%)	213 (98.2%)	
Hydrocele	5 (77.8%)	59 (98.3%)	64 (96.3%)	
Umbilical hernias	22 (100%)	11 (100%)	33 (100%)	
Intussusception	15 (87%)	16 (100%)	31 (93.3%)	
Postsurgical complications	6 (88.9%)	11 (100%)	17 (95.8%)	
Small bowel obstruction	7 (62.5%)	2 (40%)	9 (55.8%)	
Pyloric stenosis	4 (100%)	6 (100%)	10 (100%)	
Infection	270 (92.8%)	93 (92.1%)	363 (92.6%)	<.0001
Abscess/cellulitis	220 (95.8%)	68 (94.4%)	288 (95.5%)	
Wound Infection	43 (81.7%)	9 (81.8%)	52 (81.7%)	
Appendicitis	2 (100%)	8 (100%)	9 (100%)	
Trauma/Burns	131 (66.9%)	75 (59.1%)	206 (63.8%)	<.0001
Orthopedic trauma	37 (63.6%)	18 (39.1%)	54 (52.7%)	
Laceration/soft tissue injury	37 (89.1%)	4 (44.4%)	40 (81%)	
Burns/burn complication	4 (20%)	28 (90.3%)	32 (63.9%)	
Blunt abdominal trauma	19 (78.1%)	10 (100%)	29 (84.6%)	
Trauma NOS	7 (47.6%)	5 (31.3%)	12 (39.3%)	
Head injury	6 (38.1%)	1 (16.7%)	7 (32.2%)	
Congenital anomaly	102 (87.7%)	113 (91.5%)	215 (89.7%)	<.0001
Anorectal malformation	40 (93.1%)	41 (95.3%)	81 (94.2%)	
Hirschsprung's disease	40 (80.6%)	24 (100%)	64 (86.9%)	
Hypospadias	5 (100%)	20 (100%)	25 (100%)	
Undescended testis	8 (92.3%)	13 (92.9%)	22 (92.6%)	
Gastroschisis	4 (100%)	1 (25%)	5(62.5%)	
Oncology/Masses	19 (89.3%)	38 (88.4%)	57 (88.7%)	<.0001
Cystic hygroma, lymphatic or vascular malformation	2 (100%)	14 (93.3%)	16 (94.2%)	
Soft tissue mass NOS	4 (100%)	12 (100%)	16 (100%)	
Abdominal malignancy	2 (40%)	4 (100%)	5 (71.1%)	
Subspecialty	55 (84.1%)	101 (84.9%)	156 (84.6%)	.0077
Urology	31 (91.3%)	61 (87.1%)	92 (88.5%)	
ENT	6 (100%)	29 (90.6%)	35 (92.1%)	
Orthopedic surgery	17 (88.5%)	11 (73.3%)	28 (81.9%)	
Neurosurgery	1 (12.5%)	0 (0%)	1 (9.4%)	
Total	787 (85.9%)	628 (85.7%)	1415 (85.8%)	.953

Total operations are presented first with the overall operate rate for the surgical pathology at each hospital in parentheses (incidence of operative intervention for disease/incidence of total disease presentation at each hospital).
Statistical comparison represents the difference in operative rates between the two hospitals for each category. Statistical tests (*P* value) represent either Student's *t* test, Wilcoxon rank sum test, or chi-squared test.
ENT, otolaryngology; *NOS*, not otherwise specified.

The overall mortality for inguinal hernias and appendicitis was 0%, overall mortality for surgical infections was less than 1%, and trauma was less than 2%. Higher mortality was noted for ARM, Hirschsprung disease, gastroschisis, and intussusception, specifically for patients who had advanced disease or who were septic at time of presentation. Interestingly, Lacor only experienced deaths in the congenital anomaly category of disease—usually for late presentation of gastrointestinal obstruction. However, the prospective databases used in this study do not allow for perioperative risk stratification, making a more detailed analysis of overall inpatient or postoperative mortality as well as comparison between hospitals difficult.[45–47]

There are multiple studies, largely from high-income countries, that suggest improved clinical outcomes when pediatric subspecialty-trained surgeons perform complex pediatric procedures for neonatal cases,[48] congenital diaphragmatic hernias,[49] and pyloric stenosis.[50] However, other studies suggest the overall risk of complications for emergency procedures such as appendectomies does not differ between pediatric and general surgeons.[51] The majority of these studies also conclude that operative volume is the most important criteria in outcomes as opposed to specialty training.[51] This is also suggested by numerous studies in global adult general surgery literature that suggest task-shifting and task-sharing initiatives can increase access while maintaining appropriate outcomes for standard procedures.[52–54]

In addition to general surgeons at Lacor and Soroti performing safe surgery, the data from this investigation also support that the general surgeons are directly addressing an equity gap in pediatric surgical access in Uganda. In a previous study using the Surgeons OverSeas Assessment of Surgical Need survey, investigators noted that 81.9% of Ugandan children surveyed with a surgical condition were from rural areas.[16] Furthermore, the authors noted that 79% of all untreated surgical disease was located in rural areas (in contrast to 21% of untreated disease noted in urban communities). As demonstrated by the heatmaps in this investigation, the vast majority of children presenting to each hospital were from rural areas of northern and eastern Uganda. Additionally, from previous publications using the prospective database of pediatric surgical admissions from Mulago National Referral Hospital in Kampala, which spurred the prospective database at Soroti and Lacor,[9,25] we know that children from Teso and Acholi tribes from eastern and northern Uganda are underrepresented. However, both of these tribes make up the majority of admission in Soroti (89%) and Lacor (60%), respectively.

Investing in pediatric surgical capacity initiatives has large economic benefits

A large majority of the pediatric surgical case volume at Soroti and Lacor were emergency procedures, including trauma and surgical infections as well as standard general surgical procedures

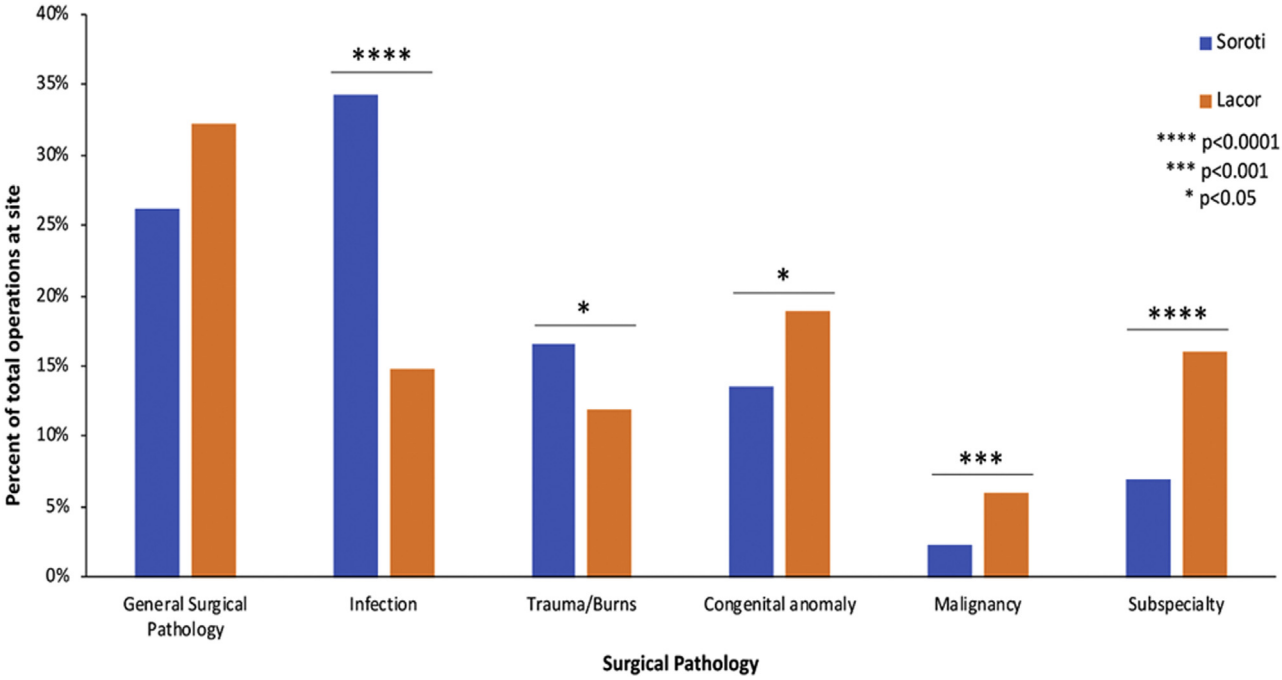

Fig 2. Pediatric operations by surgical pathology category at Soroti and Lacor Regional Referral Hospitals.

Table III
Distribution of overall in-hospital mortality by Surgical Pathology at Soroti and Lacor Regional Referral Hospital

Surgical pathology		Site	Age	Sex	Operation	Cause of death (if known)
General surgical pathology						
1	Intussusception	Soroti	9 y	Female	Laparotomy	Multisystem organ failure at presentation
2	Intussusception	Soroti	4 y	Male	Laparotomy	Septic at presentation, died immediately after operation
3	Intussusception	Soroti	6 mo	Male	Laparotomy	Septic at presentation, died immediately after operation
4	Intussusception	Soroti	6 mo	Female	None	Septic at presentation, died hospital day 1
5	Pyloric stenosis	Soroti	7 mo	Male	Gastrojejunostomy	–
6	Small bowel obstruction	Soroti	5 d	Male	None	Septic at presentation, died hospital day 1
Infection						
7	Wound infection (Ankle)	Soroti	8 mo	Male	Arthrotomy	Septic at presentation, died immediately after operation
8	Bowel perforation	Soroti	2 y	Male	Laparotomy	Septic at presentation, died immediately after operation
Trauma/Burns						
9	Ruptured spleen	Soroti	9 y	Male	Laparotomy	Died from injury
10	Laceration/soft tissue injury	Soroti	4 y	Male	None	Died from injury
11	Burns	Soroti	1 y	Female	None	Died from injury
12	Blunt abdominal trauma	Soroti	5 mo	Male	None	Died from injury
13	Head injury	Soroti	9 y	Male	None	Died from injury
Congenital anomaly						
14	Anorectal malformation	Soroti	3 d	Male	Colostomy Creation	Died immediately after colostomy creation
15	Anorectal malformation	Lacor	2 d	Male	Colostomy Creation	Respiratory failure (ARDS)
16	Anorectal malformation	Soroti	4 d	Male	None	Septic at presentation, died hospital day 1
17	Anorectal malformation	Soroti	3 d	Female	None	Septic at presentation, died hospital day 1
18	Hirschsprung's Disease	Soroti	1 d	Male	Colostomy Creation	–
19	Hirschsprung's Disease	Soroti	6 mo	Female	None	–
20	Hirschsprung's Disease	Soroti	3 d	Female	None	Septic at presentation, died hospital day 1
21	Hirschsprung's Disease	Soroti	21 d	Male	None	Septic at presentation, died hospital day 1
22	Gastroschisis	Soroti	1 d	Male	Fascial Repair	–
23	Gastroschisis	Lacor	1 d	Female	Fascial Repair	Died 3 d after operation
24	Gastroschisis	Lacor	1 d	Female	None	Premature and septic at presentation
25	Gastroschisis	Lacor	1 d	Female	None	Septic at presentation
26	Gastroschisis	Lacor	1 d	Female	None	Septic at presentation
27	Omphalocele w/ intestinal atresia	Lacor	1 d	Female	Laparotomy w/ bowel resection	Died after 11 d, presumed overwhelming sepsis
28	Duodenal atresia	Soroti	9 d	Female	Laparostomy	Bowel perforation and abdominal sepsis
29	Duodenal atresia	Lacor	27 d	Female	None	Septic at presentation

such as inguinal hernia repairs. These procedures were largely responsible for the 12,000 DALYs averted and the 10.3 million USD/year economic benefit to Ugandan society by increasing pediatric surgical capacity.

There are very few direct costs associated with increasing pediatric surgical capacity in a preexisting operating room with standard adult surgical supplies. Though we did not perform a formal cost-effectiveness analysis (CEA)[55] and do not include the

direct cost of international collaborations in this study, from the Ugandan society perspective, the 10.3 million USD/year economic benefit would only be adjusted from the standard operating costs of the hospital by the opportunity cost of reduced general surgery cases. Safe pediatric surgical procedures avert disability over the lifetime of the child, leading to large economic dividends for a country's future.

Previously conducted CEA on pediatric surgical interventions have demonstrated that they are highly cost-effective with regard to a country's GDP as well as the $240 threshold applied by the World Bank.[41,56] Our group previously estimated that the prevision of a pediatric operating room in Uganda had an incremental cost-effectiveness ratio of 6.39 USD per disability-adjusted life-year averted or 397 USD per life saved.[41] Additionally, a systematic review of CEA in pediatric surgical interventions demonstrated that pediatric surgical interventions had similar cost-effectiveness ratios as standard pediatric vaccinations and bed nets for malaria prevention and were more cost-effective then multidrug antiretroviral therapy for HIV treatment.[56] These data support increasing general pediatric surgical capacity in regional referral hospitals, which can have a major impact on the burden of surgical disease in children living in Uganda. Furthermore, there is growing evidence in CEA literature that recommend equity weighted DALYs to account for care delivered to the lowest quintile of socioeconomic status patients.[57] The data suggest that some extra value should be added for care delivered to hard-to-reach populations. As discussed previously, the population in northern and eastern Uganda are rural regions that have been previously underrepresented by pediatric surgical providers, suggesting that our economic analysis may be undervaluing the overall benefit of care delivered in these regions.

Pediatric surgical specific considerations for general surgeons and perioperative teams can be achieved through national and international collaborations

Both regional hospitals in this study have long standing national and international collaborations with pediatric surgery teams, which includes pediatric anesthesia and nursing. The data in this report did not include patients before the 2015 stakeholders' meeting, negating the ability to perform a time-course analysis of pediatric surgical volume and clinical outcomes with respect to the onset of international partnership and increased in-country linkages. However, qualitatively, the relationships established between the regional hospitals and their clinical partners were fundamental in increasing pediatric surgical support at both hospitals. The Italian charity Surgery for Children has been conducting annual 3-week outreach camps to St Mary's Lacor Regional Referral hospital since 2006.[58] The organization specifically focuses on skill transfer in pediatric surgery, pediatric urology, pediatric anesthesia, and pediatric surgical nursing management. The pediatric surgery team at Mulago National Referral Hospital and institutional collaborations at the University of British Columbia as well as the nonprofit organization Global Partners in Anesthesia and Surgery have a similar long-standing relationship with Soroti Regional Referral Hospital.[59,60] All institutional relationships again focus on service delivery and skill transfer to the general surgery team as well as the anesthesia and nursing teams.

Although short-term surgical camps are not sustainable solutions for service delivery, long-term relationships between partners can provide opportunities for training local surgeons and anesthesia providers in different surgical and anesthetic techniques specific for children and provide ongoing education.[21,61]

Limitations

Significant variability exists in published disability weights, which can affect the accuracy of DALY calculations. To adjust for this limitation, we used conservative published DW estimates and used both pediatric- and LMIC-based DW when possible. We also concentrated on treatment-based DALYs averted. Although this was more conservative and easier to quantify using the data in this investigation, this significantly undervalues the nonoperative care delivered by surgeons and thus is an underestimation of the true effect size of this study. Additionally, we were unable to risk adjust surgical conditions given the limitations of the database making more rigorous comparisons of in-hospital mortality between institutions inappropriate.

In conclusion, the results of this investigation support increasing pediatric surgical capacity at regional hospitals in East Africa through initiatives aimed at training and support of general surgeons, anesthesia providers and perioperative care teams. Institutional collaborations can support pediatric surgery access in rural regions in LMICs, where many populations cannot access higher levels of care. General surgeons can provide effective essential pediatric surgery in rural regional hospitals, which can have significant economic benefits.

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Conflict of interest/Disclosure

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Supplementary materials

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