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SURGICAL SYMPOSIUM CONTRIBUTION

Unifying Children's Surgery and Anesthesia Stakeholders Across Institutions and Clinical Disciplines: Challenges and Solutions from Uganda

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Abstract

Background There is a significant unmet need for children's surgical care in low- and middle-income countries (LMICs). Multidisciplinary collaboration is required to advance the surgical and anesthesia care of children's surgical conditions such as congenital conditions, cancer and injuries. Nonetheless, there are limited examples of this process from LMICs. We describe the development and 3-year outcomes following a 2015 stakeholders' meeting in Uganda to catalyze multidisciplinary and multi-institutional collaboration.

Methods The stakeholders' meeting was a daylong conference held in Kampala with local, regional and international collaborators in attendance. Multiple clinical specialties including surgical subspecialists, pediatric anesthesia, perioperative nursing, pediatric oncology and neonatology were represented. Key thematic areas including infrastructure, training and workforce retention, service delivery, and research and advocacy were addressed, and short-term objectives were agreed upon. We reported the 3-year outcomes following the meeting by thematic area.

Results The Pediatric Surgical Foundation was developed following the meeting to formalize coordination between institutions. Through international collaborations, operating room capacity has increased. A pediatric general surgery fellowship has expanded at Mulago and Mbarara hospitals supplemented by an international fellowship in multiple disciplines. Coordinated outreach camps have continued to assist with training and service delivery in rural regional hospitals.

Conclusion Collaborations between disciplines, both within LMICs and with international partners, are required to advance children's surgery. The unification of stakeholders across clinical disciplines and institutional partnerships can facilitate increased children's surgical capacity. Such a process may prove useful in other LMICs with a wide range of children's surgery stakeholders.

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Introduction

Importance of unifying stakeholders across disciplines

Recent studies have highlighted the substantial unmet need in global surgery and anesthesia care and the importance of children's surgical conditions [1–4]. The new global commitment to the Sustainable Development Goals and Universal Health Coverage in low- and middle-income countries (LMICs) requires collaborative solutions across clinical disciplines [4], high-income country (HIC) and LMIC partners [5] and implementation at different levels of the healthcare system [6].

Recent initiatives have highlighted the interdependence of clinical disciplines to address unmet global surgical needs. The World Health Organization has recently supported the development of National Surgical, Obstetric and Anesthesia Plans (NSOAPs) to improve surgical access [7–9]. The Global Alliance for Surgery, Obstetric, Trauma, and Anaesthesia Care (The G4 Alliance) was developed to unify stakeholders and strengthen surgical systems through consensus surgical indicators [10]. The Global Initiative for Children's Surgery (GICS) has proposed "Optimal Resources for Children's Surgery" in LMICs through multidisciplinary stakeholders [6].

At the national level, expansion of perioperative care to include anesthesia and nursing has had marked benefits in LMICs [11, 12]. Improved surgical outcomes have resulted from partnership with pediatric oncology, neonatology and community health-worker networks in LMICs. Standardizing chemotherapy protocols in LMICs have demonstrated benefits in children with cancer [13], though investigations remain limited to selected diseases and institutions. Multidisciplinary care following neonatal surgery in Nigeria was associated with improved postoperative mortality [14]. The integration of pediatric trauma care with injury prevention networks in LMICs has recently grown [15]. Specialty hospitals utilizing the principles of community-based rehabilitation have greatly expanded club-foot care globally [16] and have scaled up both service delivery and training of orthopedic surgeons in LMICs [17].

Children's surgical care in Uganda

Children's surgical care in Uganda in 2015 was similar to many LMICs, with significant limitations in surgical capacity and substantial unmet need [18–22]. The government sector had insufficient resources to match the demands of a pediatric population of over 20 million children [2]. Two clinically based Ugandan pediatric general surgeons served a population estimated to require 200 pediatric surgeons [23]. Furthermore, training in pediatric anesthesia and children's surgical subspecialties was almost completely absent [24, 25]. Large infrastructure gaps in the public sector limited care, with one dedicated pediatric general surgery unit, one neonatal intensive care unit (NICU) without ventilators and one pediatric intensive

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care unit (PICU) in the country, all located in the capital city. There was also no national referral system between different levels of the healthcare system including specialty hospitals.

The result was multiple, local and international groups individually confronting these challenges without a forum to communicate program aims, challenges and lessons learned. For example, clinical and surgical training programs were beginning to develop between local partners and international collaborators, but remained isolated between specific institutions. This fragmented health system for children's surgery led a small group of Ugandan and international pediatric general surgeons and anesthesiologists to organize a stakeholder's meeting to directly address the gap in coordination and collaboration between institutions involved in the surgical care of children within the country.

Stakeholders' meeting

The 1-day stakeholders' meeting, which followed a Uganda national surgical collaborators' conference, was held in Kampala, Uganda, in September 2015 [26]. Multiple long-standing personal and organizational relationships composing an unofficial children's surgery network facilitated the meeting. A wide range of stakeholders were represented (Table 1).

The meeting initially established the challenges and unmet needs facing children's surgery in Uganda. Selected concerns included a lack of care coordination for complex surgical disease such as congenital malformations and cancer. The need for dedicated children's operating rooms, increased critical care resources and increased capacity of regional hospitals to perform children's surgery were also emphasized. Additional sessions highlighted surgical subspecialties, anesthesia, nursing, nutrition and current work in research, policy and child health.

Breakout groups then addressed four key thematic areas: infrastructure, training and workforce retention, service delivery, and research and advocacy. Specific short- and medium-term action plans were developed. These included the creation of a foundation for children's surgery in Uganda to help coordinate children's surgical care. Other short-term objectives included:

1. Expanding surgical outreach camps for local pediatric surgical groups to rural hospitals and continued presence of international organizations providing service delivery;
2. Promoting a hybrid training model with both in-country children's surgery training complemented by international HIC training as needed and increased training opportunities for care providers in rural hospitals;
3. Increasing research capacity including defining surgical need, congenital anomaly burden, pediatric injury research and
4. Increasing infrastructure for children's surgery operating rooms and neonatal and pediatric intensive care wards.

Components critical to success of stakeholders' meeting

The strength of the stakeholder's meeting was the broad representation from diverse medical and surgical disciplines from various levels of the health system in Uganda. Furthermore, representation included both local and international partners from academic institutions, faith-based collaborators and other non-governmental organizations (NGOs). The meeting built on previously established relationships and existing in-country networks to bridge clinical and institutional divisions. Other key aspects to this process were: 1. The stakeholders' meeting was a Ugandan-led initiative; 2. there was a shared vision to improve surgical care for children in the absence of personal or institutional agendas; 3. most of the NGOs invested in children's surgery and represented at the meeting had 10–20 years of engagement in Uganda; and 4. crosscutting clinical areas such as pediatric anesthesia and perioperative care, neonatology, oncology and nursing were emphasized.

Three-year outcomes following the stakeholders' meeting by thematic area

Given the importance of clinical collaboration in global children's surgery and anesthesia but with sparse evidence evaluating this process in LMICs, we reviewed our 3-year outcomes following the stakeholders' meeting. Through progress reports and in-person interviews, we analyze the impact on quality and capacity of children's surgery in Uganda by thematic areas: infrastructure, service delivery, training (including subspecialties) and research.

Infrastructure

Insufficient children's surgery, anesthesia and pediatric intensive care infrastructure was a key impediment to service delivery, especially in rural hospitals. Following the stakeholders' meeting in 2015, there has been a significant increase in the number of dedicated pediatric operating rooms in Uganda, initially through the work of

Table 1 Key organizations represented at stakeholder's meeting or developed subsequently

Organization	Nationality	Predominate thematic area	Clinical specialty	Successes	Challenges faced
Mulago Hospital	Uganda	Service delivery, training, research	Pediatric general surgery, anesthesia, NICU, oncology, nursing, nutritionists	Outreach camps to rural hospitals COSECSA pediatric surgical training site Pediatric anesthesia training site	Poor referral system Insufficient capacity for children's surgery Large infrastructure/ resource consumption More focus on nursing training
Mbarara Hospital	Uganda	Service delivery, training, research	Pediatric general surgery	COSECSA training site Increase surgical capacity Archie/KidsOR dedicated operating space	Lack of pediatric ICU
Soroti Hospital	Uganda	Service delivery	General surgery	Service delivery in rural regional hospital Intern training Scholarly work	Lack of subspecialties ICU capacity Infrastructure Consumables
St. Mary's Lacor Hospital	Uganda	Service delivery	General surgery, pediatric general surgery	Service delivery in rural regional hospital	Lack of subspecialties ICU capacity
KidsOR	Scotland	Infrastructure	Non-governmental organization	Fully equip pediatric operating rooms (2 built, 3 under development)	Maintenance, repair and replacement of invested equipment Lack of local biomed personnel
CoRSU	Uganda	Service delivery, training	Pediatric, orthopedic and plastic surgery	5000 pediatric reconstructive cases/year including cleft lip/palate and limb salvage Specialist training in pediatric orthopedics and plastic surgery Community-based rehabilitation programs Scale-up of club-foot training	Expanding training program for pediatric subspecialty programs Harmonizing with public sector Scaling up crosscutting programs
CURE Hospital	Uganda	Service delivery, training	Pediatric neurosurgery	Subspecialty care in regional hospital	Harmonizing with public sector
GPAS	Uganda International Partners	Training	Pediatric general surgery, pediatric anesthesia	Training and workforce expansion	Sustainable funding, advocacy
Uganda Paediatric Association	Uganda	Training, advocacy	Multiple clinical pediatric subspecialties	Advocacy, collaboration between pediatric specialities	Integration of specialties
Uganda training alliance	Uganda–Canada	Training	Pediatric general surgery, pediatric anesthesia	International pediatric surgery, anesthesia, urology fellowship	Expansion of program to other disciplines Sustainability
Surgery for children	Uganda–Italy	Service delivery, training	Pediatric general surgery, pediatric anesthesia, pediatric urology	Service delivery in rural regional hospital Concentration on anorectal and urogenital anomalies Training local surgeons and anesthesia providers Inspiring young surgeons toward children's surgery careers	Sustainability Long-term goals

Table 1 continued

Organization	Nationality	Predominate thematic area	Clinical specialty	Successes	Challenges faced
Pediatric urology collaboration	Uganda–Uppsala	Training, service delivery	Pediatric urology	Training in pediatric urology Bilateral exchange/teaching Establishment of DSD clinic	Expansion of training and clinical programs Sustainability
Surgical oncology collaboration	Baylor–Uganda Cancer Institute	Training, service delivery, research	Pediatric general surgery, anesthesia, perioperative nursing	Capacity building for medical and surgical oncology International observerships in pediatric surgical oncology	Integration with existing programs Support for specialized areas of pediatric surgery
McMaster University	Canadian	Training, research	Pediatric general surgery	Implemented Trauma Registry in Mbarara	Collaborations with existing partners Patient registration system
Oxford University	UK	Training, research	Pediatric general surgery	Support for fellowship training program	Monitoring capacity building, local leadership, and program development

Additional Organizations Represented at Meeting: Makerere University—Johns Hopkins University Research Collaboration, Archie Foundation, Baby Watoto Orphanage, Mbarara University of Science and Technology, St. Joseph's International Outreach Program

COSECSA College of Surgeons of East, Central, and Southern Africa, *ICU* intensive care unit, *CoRSU* Comprehensive Rehabilitation Services of Uganda, *GPAS* Global Partners in Anesthesia and Surgery, *DSD* disorders of sexual differentiation

the ARCHIE Foundation, a UK-based Charity, and now with the ongoing development of the service by Kids Operating Room (KidsOR), a UK-based NGO.

The first dedicated pediatric operating room in Uganda opened in the China–Uganda Friendship Hospital at Naguru, Kampala, in April 2015. Through the stakeholders' meeting, relationships were established with other pediatric surgeons in Uganda, and in November 2016, a second pediatric operating room was opened in Mbarara (Fig. 1). The location of the second unit was influenced by the presence of a qualified pediatric surgeon, locally identified priorities and potential for training opportunities. An assessment of further expanded operating room capacity was carried out in January 2018, in parallel with plans for three dedicated pediatric operating rooms in the refurbished Mulago Hospital in Kampala, which is scheduled to be completed in early 2019. Further collaborations

Fig. 1 KidsOR operating theater in Mbarara, Uganda

between KidsOR and other hospitals in Uganda are ongoing.

Service delivery

One of the highlighted deficiencies in surgical service delivery was a lack of coordinated care between specialty hospitals and the public sector. This led to the creation of the Pediatric Surgical Foundation, a Ugandan organization open to individual and organizational membership. The foundation has been officially recognized by the Ugandan government and is intended to help coordinate a formal network for both local and international groups caring for children with surgical needs. The foundation may also allow for central coordination with the Ugandan Ministry of Health.

In order to address the significant backlog of elective cases and poor surgical access in rural areas of Uganda, stakeholders supported the continued coordination and standardization of short-term surgical outreach missions or surgical camps. Surgical camps include both Uganda-led surgical outreach missions (usually 1–2 weeks) to district or regional hospitals in rural areas of the country and short-term missions from international partners. Over the last 3 years, multiple outreach camps in pediatric general surgery, urology and surgical oncology have been conducted (Table 2). A majority of the cases have been elective definitive repairs of anorectal malformations, Hirschsprung's disease and urological conditions. The coordination of these camps has qualitatively increased since the stakeholders' meeting, with sharing of camp data, site-specific strategies and ongoing challenges.

After the stakeholders' meeting in 2015, training and skill transfer to a wide range of providers remained an essential component of camps (Table 3). The camp forum facilitated hospital leaders and administrators' discussion of efficient methods of high-quality surgical care delivery. Local partnerships between Ugandan institutions have supported service delivery at the regional level, such as Mbarara Hospital, Masaka Hospital, St. Mary's Hospital Lacor and Soroti Hospital. Increased regional collaborations between Uganda hospitals and children's surgery teams have also occurred. One such collaboration between Mbarara and Fort Portal regional hospitals in western Uganda has developed to assist with complex elective pediatric surgery cases in the more rural center.

The need for resource guidelines to inform appropriate service delivery at various levels of the health system was emphasized at the meeting. This, in part, encouraged the development of the Optimal Resources document of GICS, which will require adaptation to the Uganda context [6].

Training

Stakeholders felt that increased specialty training was the most realistic solution to be addressed through collaboration. Local colleagues emphasized the impact of successful collaborations and capacity building on recruitment of young local surgeons and anesthesia providers—the leaders of the next generation. The stakeholders' meeting catalyzed the coordination of multiple independent training programs and allowed several institutional training relationships to grow and expand. With the expansion of the pediatric general surgery fellowship training in Uganda, four pediatric general surgery fellows have been trained over the last 3 years, more than doubling the number of pediatric surgeons. Mulago Hospital had been an official pediatric surgery training site through the College of Surgeons of East, Central, and Southern Africa (COSECSA), but fellows lacked funding, faculty was limited, and there were limited international training opportunities. Following the stakeholders' meeting, international collaborators began financially supporting in-country training of pediatric general surgery trainees as local sources of support were not available. Additionally, through the long-standing relationship between the pediatric surgery fellowship at Mulago and the Division of Pediatric Surgery at the University of British Columbia (UBC), UBC formed and funded a Ugandan fellowship for 1 year at Vancouver's British Columbia Children's Hospital. This fellowship was designed to supplement in-country training in Uganda with a competency-based curriculum as per the Royal College of Physicians and Surgeons of Canada (CanMEDS) competency domains [27]. The pediatric surgery fellowship has continued to develop with linkage between Mulago and Mbarara hospitals as a joint COSECSA training site, further increasing pediatric surgical training capacity. Additional international academic collaborations have led to extended international observerships for pediatric surgery fellows to supplement their exposure to pediatric intensive care training and laparoscopy.

This training model has expanded to include a UBC—Pediatric Anesthesia fellowship and Pediatric Urology fellowship. In addition, Inter-African partnership has increased pediatric anesthesia training in Uganda. Currently, the Anesthesia Department at Mulago has linked with the University of Nairobi and Red Cross War Memorial Children's Hospital (RCWMCH), sponsored by the World Federation of Societies of Anaesthesiologists (WFSA) and African Pediatric Fellowship Programme (APFP), to train an additional pediatric anesthesiologist who has since returned to practice in Uganda.

The Italian-based organization "Surgery for Children" has strengthened their long partnership with the surgical and anesthesia team at Lacor Regional Hospital and Gulu

Table 2 Outcomes of surgical camps including achievements and perceived challenges

Location/year	Groups	Total operations	Elective operations	Major complications	Outreach success	Outreach challenges
Lacor (November 2015)	Surgery for children	44	43/44	1 Reoperation (abdominal sepsis)	Education of Gulu medical student and Mbarara residents Preoperative radiological studies	Lack of postoperative nursing care Lack of neonatal care
Mbarara (January 2016)	Mbarara and Mulago group	23	21/23	1 Reoperation	Strength Mulago–Mbarara collaboration Clear backlog of complex elective cases Resident training	Lack of ICU limited practice Potential burden on local hospital
Mbarara (November 2016)	Mbarara and Mulago group	25	23/25	0	Strength Mulago–Mbarara collaboration Clear backlog of complex elective cases Resident and fellow training	Lack of ICU limited practice including postoperative ventilator availability
Mulago/Soroti (2016)	Mulago and UBC group	120	–	1 Mortality	Patient satisfaction survey and patient empowerment	Lack of alternative stable IV access for complex cases Lack of urgent laboratories
Lacor (2016)	Surgery for children	53	51/53	5 Reoperations (infections) 1 Mortality (sepsis)	Education of Gulu medical students and Mbarara residents Preoperative radiological studies	Lack of postoperative nursing care Lack of neonatal care
Mbarara (April 2017)	Mbarara and Mulago group	36	35/36	1 Mortality 2 Reoperations (infection)	Fellow training Subspecialty collaboration	Pediatric ICU care (especially infants) Post-op nursing care
Uganda Cancer Institute (November 2017)	Mulago group and GPAS	13	13/13	1 Mortality 1 Unresectable tumor	Cleared backlog of solid organ tumors at UCI Utilized UCI operative resources	Lack of ICU space limited cases and post-op care Lack of dedicated pediatric OR time
Lacor (2017)	Surgery for children	70	67/70	4 Reoperations 3 Mortalities (gastroschisis, intestinal atresia, strangulated hernia)	Education of Gulu medical students and Mbarara residents Preoperative radiological studies	Lack of postoperative nursing care Lack of neonatal care
Mulago and Uganda Cancer Institute (2018)	Mulago and UBC	107	–	3 Mortalities	Focused on pediatric surgery fellow education	Limited ICU access Lack of real-time laboratories, e.g., ABGs to guide resuscitation

UCI Uganda Cancer Institution, *ICU* intensive care unit, *GPAS* Global Partners in Anesthesia and Surgery, *UBC* University of British Columbia, *ABG* arterial blood gas, – specific data not available

Table 3 Surgical and perioperative outreach teams involved in camps including trainees

Location of camp	Lacor Nov 2015	Mbarara Jan 2016	Mbarara Nov 2016	Mulago and Soroti 2016	Lacor 2016	Mbarara April 2017	UCI Nov 2017	Mulago and UCI 2018	Lacor 2017
Institutions	Surgery for children	Mulago and Mbarara group	Mulago and Mbarara group	UBC	Surgery for children	Mulago	GPAS and Mulago group	UBC	Surgery for children
Pediatric general surgeons	1 UG 1 Italy	2 UG 1 US	3 UG 2 US	2	3 Italy	2 US 2 UG	2 UG 3 US	5	1 UG 4 Italy
Pediatric surgery fellows	0	0	1 UG	1	0	2 UG 1 US	2 UG	3 UG	0
Surgery residents	1 UG	2 UG	2 UG	2	1 UG	3 UG	2 UG 1 US	3 UG	1 UG
Medical officers	1 UG	2 UG	2 UG	3	1 UG	0	1 UG	1 UG	1 UG
Anesthesiologists	1 UG 2 Italy	3 UG	3 UG	1	1 UG 3 Italy	3 UG	0	2 UG 1 Can	1 UG 3 Italy
Anesthesia residents	0	4 UG	3 UG	5–7		3 UG	0	4 UG 1 Can	1 Italy
Anesthesia officers	2 UG	0	0	2	2 UG	2 UG	3 UG	1 Can	2 UG

Can Canada, *UCI* Uganda Cancer Institute, *UG* Uganda, *US* United States, *UBC* University of British Colombia

University (Gulunap Project www.gulunap.unina.it). Their annual training and service trips to Lacor Hospital allow them to work closely with local staff to assist in training medical students, clinical officers, medical officers, anesthesia officers and operating room technicians. McMaster University and the St. Joseph's International Outreach Program have continued to support training in surgery, anesthesia and orthopedic surgery through clinical attachments in Canada as well as short-term visits of teams from Canada to perform skills-based workshops such as an orthopedic sawbones course, evidence-based medicine and laparoscopy. In addition, collaborations at CoRSU Rehabilitation Hospital have expanded local training opportunities in pediatric orthopedic and plastic surgery, both for trainees at CoRSU and in the public sector.

A substantial portion of children's surgical and anesthesia care continues to be provided by general surgeons, general doctors and anesthesia officers. As such, a training curriculum for general surgeons and medical officers in children's surgical emergencies has been developed and piloted in 2018 to a group of 13 rural providers with plans to scale up the course ("Appendix"). Similarly, the SAFE (Safer Anaesthesia from Education) Paediatric Anaesthesia Course developed by the Association of Anaesthetists of Great Britain and Ireland (AAGBI) and WFSA has been expanded over the last 3 years to anesthesia providers throughout the country. Lastly, a growing partnership with the Uganda Pediatric Association (UPA) has led to pediatric surgeons' involvement in the yearly UPA conferences, with presentations on surgical topics relevant to general pediatric providers.

Children's subspecialties

Unmet need and general backlog of elective cases in the public sector exist in the majority of the children's surgical specialties including orthopedic surgery, plastic surgery, neurosurgery, otolaryngology and urology [28, 29]. This has led to the formation of specialty hospitals within Uganda such as the Comprehensive Rehabilitation Services of Uganda (CoRSU) Hospital in Kisubi that specializes in pediatric orthopedic and plastic surgery reconstruction procedures. The hospital performs more than 5000 pediatric reconstruction cases each year through a network of rural partners that refer children to the hospital.

Despite a growing number of orthopedic surgeons within the country, an orthopedic surgery training program at Mulago Hospital and increasing interest in subspecialization, Uganda still does not have a pediatric orthopedic surgery fellowship. CoRSU does not have a formal academic partnership with Makerere University, despite close proximity, partially due to the constraints of University training requirements. Through the stakeholders' meeting, the paradigm of COSECSA training programs was discussed and remains a possible solution for pediatric orthopedic surgery training in Uganda. McMaster and UBC through the Uganda

Sustainable Trauma and Orthopaedic Program (USTOP) program have also continued support of both in-country and international training [30]. For pediatric urology, a recent partnership with Uppsala, Sweden, has provided bilateral training opportunities and creation of a clinic to address children with disorders of sexual differentiation (DSD).

Multidisciplinary oncology care was highlighted at the stakeholders' meeting. Through the meeting and an ongoing pediatric solid organ tumor board, the pediatric oncology group at the Uganda Cancer Institute and the pediatric surgery and radiology teams at Mulago increased their clinical collaboration. The clinical collaboration with pediatric oncology and surgical oncology has also been strengthened through the Baylor Global HOPE (Hematology–Oncology Pediatric Excellence) program. This has led to a more integrated solid organ tumor board and pooled resources for infrastructure challenges. Nonetheless, 3 years following the stakeholders' meeting, limitations in operating time, anesthesia and intensive care resources constrain the ability to perform complex tumor resections within treatment protocol time frames.

Research

A major emphasis of the stakeholder's meeting was to better define the burden and unmet need of children's surgery. A prospective clinical database for pediatric general surgery used in Mulago Hospital was expanded to three other sites (Lacor, Soroti and Mbarara). This database has facilitated scholarly activity for Ugandan surgeons, surgery trainees and international partners. These have included pediatric surgical epidemiology and economic analysis, as well as disease-specific outcomes. Scholarly work across specialties has proliferated broadly and children's surgery research networks have grown along with clinical and training networks, which have expanded in the last 3 years (Table 4).

Key accomplishments and lessons learned

A stakeholders' meeting followed by purposeful collaboration can result in measurable deliverables in locally identified high-priority areas of infrastructure, training, service delivery and research. The alignment of stakeholders catalyzes collaboration across thematic areas. For example, aligning growth in pediatric surgery training and harmonization with infrastructure development has led to synergistic growth in service delivery. Small purposeful projects between different stakeholders can also strengthen links between different Ugandan institutions and clinical disciplines.

Over the last 3 years, in-country and international fellowship training opportunities have grown across multiple surgical specialties including anesthesia. Close collaboration with the NGO KidsOR has facilitated the development of multiple dedicated pediatric operating rooms in Uganda. The Ugandan experience has informed the expansion of KidsOR to a global scale. The consensus-building approach of stakeholders also strengthened the relationship between remote district and regional hospitals to national referral hospitals.

Additionally, collaboration with the Uganda Pediatric Association has led to children's surgery education programs for rural general providers and pediatricians to recognize and triage children's surgical disease including congenital anomalies. Though the impact of this collaboration is difficult to measure, the number of referrals from small district hospitals to regional hospitals like Mbarara appears to be increasing over the last 3 years. Lastly, building and maintaining relationships between local and international partners requires interdisciplinary collaborations, bilateral visits, shared authorship, opportunities for Ugandan providers to present at international conferences and joint priority setting.

Remaining challenges to unify children's surgical stakeholders' in Uganda

Numerous challenges remain to improve quality and capacity of children's surgery in Uganda. Critical care, radiology and pathology require additional specialty-specific infrastructure. As infrastructure and service delivery develop, more complex surgical diseases pose new challenges. The coordination of complex surgical conditions including congenital anomalies and oncology continues to be fragmented among numerous specialties, hospitals and institutions. Despite the increase in pediatric general surgical training, subspecialty training in children's surgery including pediatric orthopedic, urology, neurosurgery and otolaryngology must be developed. In-country fellowship training programs for pediatric anesthesia and neonatology also need to be developed. A focus on nursing training in many of the collaborations is lacking and also must be addressed.

Increasing resource allocation for children's surgery from the Ministry of Health remains a key challenge as infrastructure development and workforce management ultimately depend on government financing. There continues to be limited jobs for newly trained providers specifically in the government sector, where the need is greatest. While surgical camps can help with elective backlogs, they are not sustainable solutions and cannot assist with emergencies or day-to-day challenges. There

Table 4 Selected projects and outputs from research collaborations and prospective pediatric surgery database

Year	Project theme	Output	Main findings	Action items	Presenting author	Senior author
2015	Patterns of burn care at community health centers in Uganda	Oral presentation and abstract publication	Resource shortage in community health centers hinder burn treatment	Improve burn care resources at health community facilities	HIC student	LMIC pediatric surgeon
2015	Household survey of burn incidence in Uganda	Oral presentation and abstract publication	Incidence 7:1000 people Majority in children <4 years old	Findings to guide future injury prevention campaigns	HIC medical student	LMIC pediatric surgeon
2016	Clinical outcomes following Wilms tumor resection	Final thesis	High rate of more aggressive tumors	Assess tumor biology	LMIC trainee	LMIC pediatric surgeon
2016	Surgical outcomes following intussusception	Final thesis	20% mortality Radiographic reduction not available	Early diagnosis Diversion in unstable patients	LMIC trainee	LMIC pediatric surgeon
2016	Clinical burden of ileal perforation from typhoid disease	Final thesis	20% mortality	Prevention Early diagnosis Diversion in unstable patients	LMIC trainee	LMIC pediatric surgeon
2016	Gastroschisis outcomes in Mulago Hospital	Paper	>90% mortality	Early treatment and reduction Silo alternatives TPN and nursing care	LMIC trainee	HIC/LMIC pediatric surgeon
2016	The role of physicians as advocates for patient care in rural Uganda	Oral presentation and abstract publication	Physicians advocate on personal level, experience limitations	Reduce barriers to physician-guided patient advocacy	HIC student	LMIC pediatric surgeon
2016	Promotion of collaboration and priority setting for children's surgery in Uganda	International presentation	Local stakeholder's meetings and priority setting can be useful	Follow-up in thematic areas and assess progress	LMIC pediatric surgeon	LMIC pediatric surgeon
2016	Role of rural outreach camps on service delivery of pediatric surgery	International presentation	Feasible and safe to conduct camps	Continue to assess impact on burden of disease and skills transfer	LMIC pediatric surgeon	LMIC pediatric surgeon
2016	Diabetic foot amputation	Oral presentation and abstract publication	Diabetic foot amputation is common	Implement early diabetic screening and treatment	HIC student	LMIC pediatric surgeon
2016	Social cost of ostomy	International presentation and paper	High rate of socioeconomic burden for families	Family support/counseling Economic protection Hiring nurse coordinator for colorectal program	LMIC pediatric surgeon	LMIC/HIC pediatric surgeon
2016	Epidemiology of anorectal malformations in Uganda	Final thesis	High rates of ARMs and need for staged procedures	Early diagnosis	LMIC trainee	LMIC pediatric surgeon
2016	Hand hygiene education campaign at Soroti Regional Referral Hospital, Uganda	Oral presentation and abstract publication	Low access to hand hygiene measures No prior assessment	Implement education campaign and local infection control	HIC medical student	LMIC pediatric surgeon
2016	Understanding delays in access to pediatric surgical care	Medical student project	Three delays all factor in access	Resources to reduce three delays	HIC medical student	HIC/LMIC pediatric surgeons

Table 4 continued

Year	Project theme	Output	Main findings	Action items	Presenting author	Senior author
2016	Developing pediatric surgery in Uganda	National presentation (USA)	High burden of disease and limited human resources	Role of collaborations to develop capacity	LMIC pediatric surgeon	LMIC pediatric surgeon
2016	Financial burden of clinical investigation	Oral presentation and abstract publication	Significant number of patients experience financial burden with healthcare	Develop financial policies for healthcare expense protection	HIC student	LMIC pediatric surgeon
2016	Burden of pediatric orthopedic disease in Uganda	Collaborative project	High burden of musculoskeletal disease	Prevention and early care programs	HIC medical student	HIC/LMIC orthopedic surgeons
2016	Gluteal fibrosis and sciatic nerve injury from injections	Collaborative project	Substantial burden of gluteal fibrosis	Prevention (injection and treatment)	HIC medical student	HIC/LMICs orthopedic surgeons
2016	Osteomyelitis/club-foot research	Collaborative projects	High burden of osteomyelitis and club-foot Lessons of training	Training programs/courses Club-foot lessons for scale-up	HIC/LMIC trainees	HIC/LMIC orthopedic surgeons
2016	Prevalence, burden and access to care of pediatric hernias	PhD project	Burden and epidemiology of inguinal hernias	Need for detection and treatment	LMIC general surgeon	LMIC general surgeon
2016	Barriers/Facilitators of Access to Surgical Care	Final thesis	Substantial barriers to surgical access	Implementation of programs to improve access	LMIC trainee	LMIC general surgeon
2016	Intestinal Atresia Review	Manuscript	50% mortality and median presentation at 7 days old	Early detection Alternatives for high-risk patients	HIC trainee	LMIC pediatric surgeon
2017	Understanding the journey to care for Ugandan children with rare surgical diseases	Oral presentation and abstract publication	Transport and financial constraints are critical High incidence of ARM and Hirschsprung's disease	Capacity building of health workforce More effective strategies for financial protection	HIC Medical Student	LMIC pediatric surgeon
2017	Management of diabetes	Oral presentation	Education seminars effective at knowledge translation	Maintain education outreach for diabetes management	HIC student	LMIC pediatric surgeon
2017	Pediatric surgery epidemiology	National presentation	High excess mortality for selected diseases Limited human resources	Increase capacity Monitor outcomes	HICLMIC trainee	HIC/LMIC pediatric surgeon
2017	Cost-effectiveness of pediatric surgery operating room	National presentation	Favorable cost-effectiveness and economic benefit	Scale-up investment and monitor outcomes	HIC trainee	HIC/LMIC pediatric surgeon
2017	Out of pocket expenditure for pediatric surgery	National presentation	Up to 1/3 of families will incur catastrophic health expenditure	Improved financial protection for families	HIC medical student	HIC/LMIC pediatric surgeon
2017	Burden of surgical infections on operative volume	National presentation	Substantial burden of surgical infections, often due to late presentation	Early diagnosis and treatment	HIC trainee	HIC/LMIC pediatric surgeon
2017	Pediatric surgical stakeholder's meeting: a way forward for global collaborations	International presentation (World Congress of Surgery, Basel, Switzerland)	Local stakeholder's meetings and priority setting can be useful	Follow-up in thematic areas and assess progress	LMIC pediatric surgeon	LMIC pediatric surgeon

Table 4 continued

Year	Project theme	Output	Main findings	Action items	Presenting author	Senior author
2017	Trachea–esophageal fistula and esophageal atresia: a 5-year experience	National presentation (Kampala, Uganda)	Feasibility of repair in LMIC Environment and high mortality/morbidity	Critical care capacity building	LMIC pediatric surgeon	LMIC pediatric surgeon
2017	Challenges and opportunities for pediatric surgery in Uganda	National presentation (USA)	Local initiatives to strengthen capacity	Growth of international collaborations to support local priorities	LMIC pediatric surgeon	LMIC pediatric surgeon
2018	Burden of emergency procedures in pediatric surgery on operative volume	National presentation	High burden of emergency procedures, impact on wait lists, possible new metrics	Increase OR and human resource capacity Monitor impact	HIC trainee	LMIC/HIC pediatric surgeon
2018	SAFE anesthesia course in Uganda	International presentation	Feasibility and scale-up of SAFE course	Continue to scale up and monitor impact	–	LMIC pediatric anesthesiologist
2018	Congenital anomaly identification	Medical student project	Support for educational programs for front line health workers and birth personnel	Refine existing tools for anomaly identification and pilot program	HIC student	HIC/LMIC pediatric surgeon
2018	Factors affecting immunization	Oral presentation	Miscommunication and variable record keeping affect immunization practice	Implement standard practice for immunization records Increase educational outreach regarding immunization	HIC student	LMIC pediatric surgeon
2018	Quality of life with stoma	Medical student project	Substantial burden of ostomy and cost for families	Need for improved counseling with educational materials for families	HIC student	HIC/LMIC pediatric surgeon
2018	Evaluation of the Nutritional Status of Ugandan Pediatric Patients	Oral presentation and poster	25% of pediatric patients severely stunted, severe wasting in 20%	Undernutrition common Greater resources to support nutrition program	HIC student	HIC and LMIC pediatric surgeon
2018	Medical student interest in surgery	International presentation	Majority of students interested in infectious disease High rates of intent to migrate	Improve exposure to surgery and perception of surgical careers	LMIC pediatric surgeon	HIC/LMIC pediatric surgeon
2018	Postnatal care	Oral presentation	Infant mortality rate 5% 50% staff unaware of WHO guidelines	Education seminars and resource allocation	HIC student	LMIC pediatric surgeon
2018	Impact of a pediatric surgery unit	International presentation	Substantial impact of developing a unit	Scale-up and build capacity	LMIC trainee	LMIC pediatric surgeon
2018	Abdominal trauma outcomes	Oral presentation	High rate of negative laparotomy in trauma	Improve imaging capacity Develop injury prevention campaign	HIC student	LMIC pediatric surgeon

Table 4 continued

Year	Project theme	Output	Main findings	Action items	Presenting author	Senior author
2018	Pediatric trauma patients in Mbarara	International presentations	Substantial burden of injuries in children	Improved surveillance and trauma care	LMIC pediatric surgeon, HIC trainee	HIC pediatric surgeon

HIC high-income countries, *LMIC* low- and middle-income countries, *PhD* Doctor of Philosophy, *SAFE* Safer Anaesthesia from Education, *USA* United States of America

also continues to be a focus on interventions at the national referral hospital compared with rural hospitals. Development of a national referral service within the country including specialty or niche hospitals is needed and ultimately requires closer collaboration between institutions addressing children's surgery delivery and the Ministry of Health.

Next steps

Children's surgical capacity is increasing in Uganda, in part due to aligning stakeholders investing in infrastructure and human resources. At the first pediatric operating theater in Naguru, a Ugandan team of two pediatric surgeons, one pediatric anesthesiologist, two pediatric surgery fellows and multiple general surgery residents perform complex elective cases daily. Similar teams of orthopedic and plastic surgery specialists are trained in CoRSU. The ultimate goal will be to develop a sufficient number of children's surgical specialties in Uganda to make international training programs unnecessary. Continued alignment of like-minded organizations that invest in parallel and complementary themes is needed. Future aims include increased training for medical officers, general surgeons and anesthesia providers at rural hospitals, increased fellowship training programs for pediatric surgical subspecialties and more locally led research to inform practice and policy.

Continued advocacy for children's surgery at the Ministry of Health is required, including integration of children's surgery into the National Health Plan. As children's surgery crosscuts both Maternal and Child Health Policy and National Surgical, Obstetrics and Anesthesia Plans, children's surgery should be integrated into both of these agendas. Ongoing assessment of children's surgical volume, workforce and access will be needed, although no clear standards currently exist in LMICs. A recent review of surgical output highlighted the deficiency compared to global standards but did not include data on children [31].

Public policy recommendations

Policy 1 A stakeholders' meeting of local champions and international partners can be an initial step to inventory children's surgery programs, to define local challenges and context-specific solutions and to establish a children's surgery network. The network can set short- and longer-term goals based on local priorities, can grow over time and should cross-clinical disciplines.

Policy 2 Policies to inform service delivery must be implemented through the health system, including specialty or niche hospitals, and require assessment of resources at all levels of the healthcare system. Children's surgery teams at the national, regional and district levels can catalyze the progress. Rural Outreach Camps from both local children's surgery groups and international clinical partners must be centrally coordinated and standardized.

Policy 3 Children's surgery, anesthesia and perioperative care should be integrated in the development of national health policies and adapted to the local context.

Conclusion

The unification of stakeholders across clinical disciplines and institutional partnerships has increased children's surgical capacity in Uganda in key areas of training, infrastructure and service delivery. Expansion of capacity and evolution of multistakeholder engagement have created new dimensions of opportunities and challenges. Ultimately, coordination, shared decision making and distributed leadership are required to develop sustainable children's surgery in Uganda. This is dependent on collaboration of stakeholders at all levels of the health system.

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Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

Appendix: Topics for pediatric surgery emergencies workshop for general surgeons

Surgical management of children

- Anesthesia and analgesia
- Fluid management and blood transfusion
- Tubes, lines and vascular access

Neonatal emergencies and congenital anomalies

- Necrotizing enterocolitis
- Gastroschisis and omphalocele
- Neonatal intestinal obstruction
- Hypertrophic pyloric stenosis
- Hirschsprung's disease and constipation
- Anorectal malformations
- Esophageal atresia

Intestinal emergencies, bone and soft tissue infections

- Appendicitis
- Salmonella (typhoid)-associated perforation
- Intussusception
- Obstructed strangulated hernia
- Rectal prolapse
- Necrotizing fasciitis and pyomyositis
- Acute and chronic osteomyelitis

Urologic emergencies

- Acute scrotum
- Febrile urinary tract infections
- Phimosis/paraphimosis
- Urinary retention

Trauma

- Fractures
- Burns
- General pediatric trauma

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