



Children at the heart of global surgery: children's surgery in low- and middle-income countries

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Abstract: Global child health is incomplete without the inclusion of global children's surgery. Despite recent advances, many challenges exist in the field of global children's surgery. Currently, an estimated 1.7 billion children lack access to safe, affordable, and timely surgery and anesthesia care globally. The aim of this review article was to discuss challenges and achievements in the field of global children's surgery with a focus on workforce capacity, training and education, research, and financing. Almost a half of the population in many low- and middle-income countries (LMICs) is comprised of children under the age of 15. Even then, many LMICs suffer from severe workforce shortages, inadequacy of strong medical schools and children's surgery training programs, and limited research capacity and funding dedicated to children's surgery. Specifically, Malawi and Pakistan were reported to have a pediatric surgical workforce density (PSWD) of only 0.17 and 0.4 children's surgeons per million children, respectively. Unavailability of robust research and educational programs within an individual's home country has also been seen to motivate students and trainees to pursue specialized children's surgical training abroad, which further exacerbates the ongoing workforce deficiencies. Recently, the introduction of the Global Initiative for Children's Surgery has played a pivotal role in advancing the field of children's surgery, by promoting stronger LMIC representation and inclusion in advocacy, research, and education. In addition, successful international research collaborations, including the GlobalPaedSurg and GlobalSurg; training courses and programs; organizational efforts to improve infrastructure and service delivery, including KidsOR; and inclusion of children's surgery into the national surgical, obstetrics, and anesthesia plans (NSOAPs) underscore the importance of engaging LMIC colleagues and stakeholders to achieve the seemingly audacious but reasonable goal of making sure that every child has access to safe surgical care.

Keywords: Global surgery; children's surgery; low- and middle-income countries (LMICs)

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Introduction

Global child health is incomplete without the whole-hearted inclusion of children's surgery. An estimated 1.7 billion children do not have access to safe, timely, and affordable surgery and anesthesia care globally (1). In the least developed and low-income countries of the world, an

estimated 40% of the population is comprised of children under the age of 15, with the proportion exceeding 50% in Niger (2).

According to the landmark report of the Lancet Commission on Global Surgery (LCoGS), 143 million additional surgical procedures are needed in LMICs in

order to avert life-long disability and death (3). However, data on unmet surgical need (USN) specific to children's surgery remain fragmented. Smith *et al.* reported that the national proportion of pediatric USN in Uganda was 6.9%, with the proportion of USN being higher in children under the age of 5 (4). In addition, Butler and colleagues examined the USN in four low-income countries and noted that 19% of children had a surgical need, of which 62% had at least one unmet need (5). Perhaps not surprisingly, low-income countries experience a shockingly high infant mortality rate of 50 per 1,000 live births compared with 5 per 1,000 live births in high-income countries (2). Additionally, neonatal disorders contribute to 8% of disability-adjusted life years (DALYs) and congenital anomalies and perinatal conditions are responsible for 13% of surgical DALYs worldwide (6).

Surgical care has a critical role to play in preventing morbidity and mortality, protecting patients and families against impoverishing expenditures, and achieving the United Nations' Sustainable Development Goals (SDGs) (1,7-9). The third SDG (SDG-3) aims to end preventable deaths of newborns and children under 5 years of age and to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births by 2030 (10). There is strong evidence to suggest that among children above age 5 years, injuries lead to more deaths than HIV, malaria, and tuberculosis combined (11). Furthermore, given that among the 6.2 million children and adolescents who died in 2018, most deaths were due to preventable causes, the crucial role of surgery and anesthesia care in combating neonatal and child mortality cannot be overlooked (10). Since 2015, several advances—including the LGoCS; Disease Control Priorities, Third Edition's Volume on Essential Surgery; and the World Health Assembly's Resolution 68.15—have been made to actively advocate for the provision of safe and affordable surgical care to everyone, regardless of where they were born or where they live (3,12). Unfortunately, the vast need for global children's surgery remains relatively unexplored and understudied. In recent years, there has been a growing momentum in this field, but a lot of ground needs to be covered. Therefore, in this review article, we will discuss challenges and achievements in global children's surgery with a focus on workforce capacity, training and education, research, and financing (*Table 1*). We use the term "global children's surgery" instead of global pediatric surgery to encompass all sub-specialties of surgery that

cater to children's needs.

Workforce capacity

There continues to be a wide disparity in the demand and supply of children's surgeons worldwide. Interestingly, in a global comparison of the pediatric surgery workforce capacity and training requirements, Lalchandani and Dunn noted that the number of pediatric surgeons per million children was inversely related to a country's birth rate, with the highest birth rate but the lowest pediatric surgical workforce density (PSWD) noted in Ghana (13). However, there was a positive correlation between the number of pediatric surgeons and the gross domestic product (GDP) per capita in countries with GDP per capita less than US \$20,000 (13). The number of pediatric surgeons per million children ranged from 0.51 to 29.30 among the 15 high- and low-middle income countries that they examined (13). Many African and South Asian countries seem to be affected more profoundly by these gross disparities than other nations (14). For example, Malawi has only 0.17 children's surgeons per million children (15). Similarly, Pakistan has a children's surgeon density of 0.4 per million children (16). These data reiterate that children living in some of the poorest and most resource-limited regions of the world have the highest need for surgical care, yet the lowest workforce capacity to receive this care.

In addition to alleviating the burden of USN, the provision of surgical care is also linked to outcomes. Using a novel approach, Hamad *et al.* defined the critical PSWD to improve surgical outcomes globally. They reported that a survival of 80% or more in their case series was significantly associated with a PSWD of at least 4 pediatric surgeons per million children under 15 years of age (OR 16.8, P<0.0001, 95% CI: 5.66–49.88) (17). Children's surgery is a complex field with multiple subspecialties, which require specialized training and in-depth knowledge of anatomy, physiology, pharmacology, and pathology. It is important to acknowledge that children are not just "small adults" and that they have unique peri-operative care needs. Armed with this knowledge, an examination of the children's surgical workforce in addition to surgeons reveals that there are severe workforce shortages in children's anesthesia and nursing care as well (18–21). Dubowitz and colleagues reported that the per-capita anesthesia provider ratio in LMICs was often 100 times lower than in HICs (22).

Table 1 Challenges and achievements in global children's surgery

Area of focus	Challenges	Achievements
Workforce Capacity	<ul style="list-style-type: none"> Dismal PSWD and anesthesia workforce density in many countries 143 additional surgeries required in LMICs 	<ul style="list-style-type: none"> Skill development courses Infrastructure and service delivery improvement (KidsOR)
Training & Education	<ul style="list-style-type: none"> Lack of adequate training programs Lack of strong mentorship 	<ul style="list-style-type: none"> Retention of specialists trained via PAACS Opportunities by GICS
Research	<ul style="list-style-type: none"> Inequity in research opportunities and LMIC representation 	<ul style="list-style-type: none"> Truly collaborative international research efforts (GlobalSurg, GlobalPaedSurg, GICS)
Financing	<ul style="list-style-type: none"> Limited financing for children's surgery Lack of comprehensive care models for LMICs 	<ul style="list-style-type: none"> Evidence on cost-effectiveness Inclusion of children's surgery in some NSOAPs

PSWD, pediatric surgical workforce density; PAACS, Pan-African Academy of Christian Surgeons; GICS, global initiative for children's surgery; NSOAPs, National Surgical, Obstetrics and Anesthesia Care Plans.

Additionally, the World Health Organization's global surgery database indicates that among the estimated 550,000 specialist anesthesiologists worldwide, only 12% practice in Africa and southeast Asia, where one-third of the world's population lives (23). It follows that anesthesiologists specialized in care of children, and specially neonates, are even rarer.

A multitude of factors have been attributed to the current workforce deficiencies in LMICs. Particularly, a lack of adequate training programs, emigration of specialists to other countries, inequitable distribution of resources within countries, and a loss of motivation on the part of the involved surgical care providers and other stakeholders are some of the cited reasons (24,25). In a survey from six Sub-Saharan African countries, Burch *et al.* noted that better financial and educational opportunities, access to latest technology and equipment, and improved living and working environment were some of the reasons which prompted medical students to pursue further training outside of Africa (26).

Training and education

The availability of robust training programs and educational opportunities has been linked to the availability of specialist children's surgical care providers, which in turn leads to improved access to surgical and anesthesia care for children. In their case study of Uganda, Ozgediz and colleagues reported that most of the emergency surgical care is provided at first-level hospitals by medical and anesthesia officers, who have not received specialist surgical

or anesthesia residency or fellowship training (27). Many resource-limited countries and regions in the world do not have an adequate number of medical schools and pediatric surgery residency or fellowship training programs (3). Furthermore, among the schools and programs that do exist, most are situated in urban areas, which adds barriers for children in rural areas to access care and for students, trainees and providers to receive optimal exposure to a variety of disease presentations and management approaches (24). A dearth of training opportunities is not the only challenge. More recently, a decline in medical students' and graduates' interest in pursuing surgery have also been noted (28-30). Data on factors affecting the selection of pediatric or children's surgery as a career choice remain limited. In a single-country survey from Saudi Arabia, Alshahrani and colleagues noted that among more than 300 medical students and interns, none of the participants selected pediatric surgery as their specialty of choice (31). Further studies to better understand the choice of specialty and the factors influencing that decision in different parts of the world are warranted, but it is safe to suggest that the availability of strong mentorship significantly impacts a student or trainee's decision to pursue a surgical career. In this context, there is mounting evidence which underscores the importance of mentorship throughout a surgeon's life (32-34). Individuals who receive mentorship have been seen to achieve their goals earlier and experience greater career satisfaction (33). Given the low density of pediatric surgeons worldwide, especially in LMICs, many students and trainees may feel discouraged or lost when thinking about pursuing children's surgery or may decide to pursue

specialist training outside their country (26). These factors may explain why 98 out of the 168 pediatric surgery spots in Brazil went unfilled according to a 2009 survey (35). In a separate study, Chirdan *et al.* noted that 24.4% of African pediatric surgeons received their primary training outside of Africa, in Europe or North America. Moreover, a majority (52%) of pediatric surgical programs had only one or two trainees per training session, and 45% had no or irregular trainees (15). These data emphasize the need to strengthen local pediatric surgery training programs within LMICs and in addition, to establish sustainable international training and exchange opportunities to complement existing training programs.

Research

Responsibly conducted research has the potential to improve clinical practice, establish mutually beneficial collaborations, inform health policy, and enhance training opportunities. Research collaborations among colleagues from all over the world, including high-, middle-, and low-income countries have resulted in the publication of high-quality and impactful evidence in global health and global surgery. However, literature states that a certain level of inequity exists in global surgery research (36). In 2014, Elobu and colleagues conducted a survey among 43 Ugandan trainees to ascertain their perceptions of international collaborations. Only 15% of the trainees felt that the research conducted by the international or visiting groups aligned with Uganda's national interest and even though 28% of respondents did participate in one or more such research activities, none of them were given authorship in the subsequent publications (37). In another study by Elobu *et al.*, an overwhelming majority ($n=33$, 94%) of Ugandan anesthesia and surgery trainees reported that research was important to their career development and 85% wanted to publish their dissertation (38). However, most trainees considered their dissertations to be a financial burden, given that among the 81% who were receiving a scholarship, only 35% covered research costs (38). In addition to individual- or trainee-level factors that act as barriers to conducting high-quality research in global children's surgery, a multitude of system-level factors have also been implicated in hindering progress. Since the publication of the LGoCS report, impressive strides have been made in the collection of baseline surgery, anesthesia and obstetrics data on access to timely surgery,

perioperative mortality rates, and other indicators for adults (39,40). However, there have been very few global studies focused on determining metrics or indicators specifically for children's surgery (1,4,5,17,41). Numerous gaps in the global surgery community's knowledge about the accurate burden of surgical disease among children, peri-operative outcomes, backlog, cost-effectiveness, and LGoCS indicators still exist. Concerted efforts at the patient-, provider-, community-, government-, and international organization-level are required to answer these essential questions.

Financing

The systematic review conducted by Chao and colleagues played a pivotal role in dispelling the myth that "surgery is too expensive" (42). They noted that the median cost-effectiveness ratios of cleft lip or palate repair (\$47.74 per DALY), general surgery (\$82.32 per DALY), hydrocephalus surgery (\$108.74 per DALY), and ophthalmic surgery (\$136 per DALY) were similar to that of the BCG vaccine (\$51.86–220.39 per DALY) (42). In addition, they concluded that many of the essential surgical procedures were very cost-effective in resource-limited countries. Building on that, Saxton *et al.* conducted an economic analysis of children's surgical procedures in LMICs. The findings from this review suggested that nine pediatric surgical intervention categories provided a median economic benefit of greater than \$10,000 per procedure (43). The authors calculated societal economic benefit gained from surgical care using a human capital approach, which equates the value of a human life to the discounted market value of the economic output produced by an individual over an expected lifetime. These data re-emphasize that surgery is one of the most cost-effective interventions in global health, affording a 1:10 cost-benefit ratio (44). Despite the substantial evidence on the cost-effectiveness of global children's surgery, progress remains limited. There is an absence of comprehensive children's surgical care models for LMICs to implement. In many LMICs, payment for surgery is out-of-pocket. Saing reported that among 14 Asian countries, 12 had self-payment procedures in place for surgery, and only 9 had an additional health insurance provision (45). Additionally, government-subsidized surgical care was available in almost all countries; however, it is difficult to ascertain whether the quality and level of care is at par with private healthcare institutions (45).

Achievements

Despite the aforementioned challenges and deficiencies within global children's surgery, the community has achieved multiple major milestones in its efforts to improve access to safe surgical and anesthesia care for children. Concerted efforts are being made to bolster the surgical and anesthesia workforce in global children's surgery in LMICs. Short training courses aimed at enhancing theoretical knowledge and skills regarding common children's surgical conditions are being conducted in Vietnam and India (46,47). In addition, a 20-year follow-up study of African surgeons trained via the Pan-African Academy of Christian Surgeons (PAACS) showed that all of these surgeons are still practising in Africa (48). A few international organizations have also taken the lead in addressing the severe workforce and infrastructure deficiencies that exist in children's surgery. For example, KidsOR, a non-governmental organization based in Scotland, has been working to set-up operating rooms and peri-operative care units in some of the world's most resource-limited regions (49). Currently, their efforts have resulted in more than 24,000 life-saving surgeries, with more than 400,000 DALYs averted and an economic benefit upwards of eight billion US dollars (49).

Major strides have also been made in the research realm of the global children's surgical community. GlobalSurg and GlobalPaedSurg are multi-institutional, international collaborative efforts, which have brought together researchers, surgeons, anesthesiologists, nurses, and other healthcare providers with the single aim of understanding the current state of children's surgery and improving outcomes (50,51). Furthermore, the introduction and development of the National Surgical, Obstetrics, And Anesthesia Plans (NSOAPs) has been a major achievement of the global surgery community. More recently, there has been an emphasis on the mandatory inclusion of children's surgery-specific recommendations in the NSOAPs (52). Pakistan and Nigeria are among the first countries to actively incorporate children's surgery within their NSOAP process (52).

Perhaps most important has been the Global Initiative for Children's Surgery (GICS)—a consortium of healthcare providers passionately advocating and striving to ensure safe surgical care for children the world over. GICS has championed the inclusion of LMIC providers and colleagues, especially trainees in all of its efforts, from research, to advocacy, to training (53). GICS published the Optimal Resources for Children's Surgical Care (OReCS)

document which details resources required for providing optimal surgical care to all children, at all levels of hospital care (54,55). Currently, GICS has been working towards promoting local solutions, engaging local providers, forming multiple partnerships with institutions, organizations, healthcare providers, and other stakeholders, and taking the lead in creating a world where every child has access to safe and timely surgery.

Conclusions

The past five years have seen an increasing interest and investment in global surgery. Even though the momentum in global children's surgery has historically remained slow, recent efforts have translated into big advances for the community. From workforce capacity, to training and education, research, and financing, much still needs to be accomplished. The challenges facing children's surgical care providers and other relevant stakeholders may seem daunting, but recent achievements underscore the importance of prioritizing each and every child's health. No child must be left behind; only then can we truly achieve SDG-3 and actively combat neonatal, child, and adolescent morbidity and mortality.

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