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An investment in knowledge: Research in global pediatric surgery for the 21st century

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ABSTRACT

The body of literature addressing surgical and anesthesia care for children in low- and middle-income countries (LMICs) is small. This lack of research hinders full understanding of the nature of many surgical conditions in LMICs and compromises potential efforts to alleviate the significant health, welfare and economic burdens surgical conditions impose on children, families and countries. This article will evaluate the need for improved global pediatric surgery research by (1) presenting the current state of surgical research for children in LMICs and (2) discussing methods and opportunities for improvement within the political context of current global health priorities.

Introduction

The year 2015 marked a pivotal transition period for both global health and global surgery. The focus of the global health and development community transitioned from the Millennium Development Goals (MDGs) to a new set of Sustainable Development Goals (SDGs), commitments to Universal Health Coverage (UHC) and recognition of the critical need for resilient health systems. At the same time, multiple advocacy and policy efforts including the Third Edition of Disease Control Priorities (DCP3),[1] The Lancet Commission on Global Surgery (LCoGS),[2] and the World Health Assembly (WHA) resolution A 68/31 on Strengthening Emergency and Essential Surgical Care,[3] demonstrated the need for universal access to surgery and anesthesia in order to achieve these new health and development goals.

Until 2015, however, policymakers and funders had largely ignored the sizeable yet unmet need for surgical care—a treatment required for approximately 30% of the global burden of disease (GBD).[2] This lack of attention has left two-thirds of the world's population without access to surgical services,[4] has rendered health systems ill-equipped to fully address the needs of the populations they serve, and threatens to cost countries trillions of dollars in lost economic output if not addressed.[5]

Although acknowledgment of the need for improved access to surgery is now slowly growing, data and knowledge about both the current state of surgical care, as well as best methods for delivering and improving such care, are largely lacking. This information gap is greatest in low- and middle-income countries (LMICs) and is particularly apparent surrounding the surgical care of children, who comprise nearly half of the population in the least developed regions[6] (Figure 1). Research is needed to help fill these knowledge gaps.

Current picture of global surgery research

Application of research findings has the capacity to greatly improve health. For example, development of antiretroviral medications has helped to turn HIV from a fatal diagnosis to one with a fairly normal life expectancy with appropriate antiretroviral treatment.[7] Large scale improvements in maternal health over

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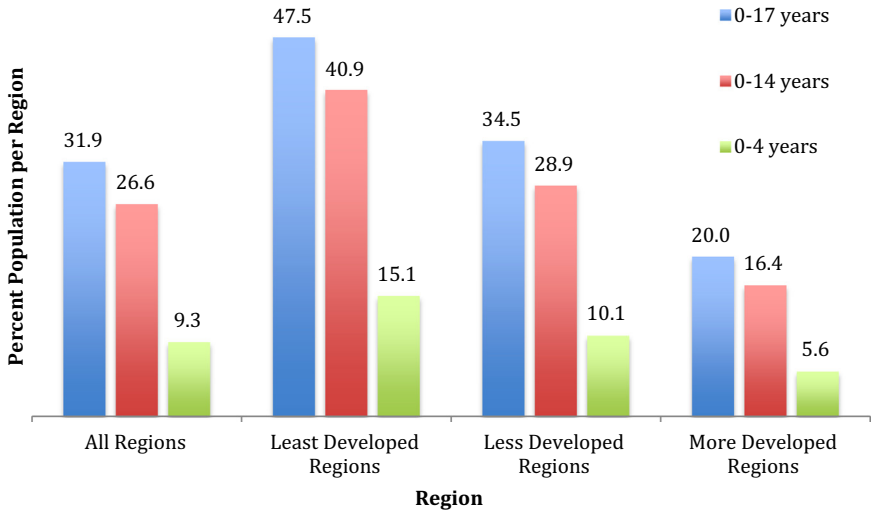

Fig. 1. Percent of population per region that are children. *Development designations of regions are from United Nations categories. More developed regions comprise Europe, Northern America, Australia/New Zealand, and Japan. Less developed regions comprise all regions of Africa, Asia (except Japan), Latin America and the Caribbean plus Melanesia, Micronesia, and Polynesia. Least developed regions are included within less developed regions and include 49 countries.[41] **Data from the United Nations 2012 World Population Prospects.[41]

the last 20 years have come in part from adaptation, testing and rapid scale-up of service delivery models.[8] Similar research-driven improvements for global surgery, however, are largely lacking due in part to a deficiency of research priority, output, capacity, and funding in regions with the greatest need.

Capacity to do research in many LMIC settings is limited by lack of time, training and funding, as well as need to focus on other priorities such as direct care delivery. People trained to do research are clustered in higher-income regions. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) estimates that only 2.2% of the world's researchers are in Africa and 3.5% are in Latin America and the Caribbean, compared to 21.9% in North America and 29.5% in Europe.[9] In addition, funding flows for global health research in general are small,[10]and funding flows to global surgery research are even smaller and declining.[11,12] There was a 50% decline in funding for surgical and anesthesia research in the United States (US) and the United Kingdom from the National Institutes of Health and Clinical Research Collaboration between 2005 and 2010; of the 12.35 billion US dollar (USD) annual budget of these two organizations, less than two million USD per year fund surgical research in underserved populations.[12]

Consequently, the highest volume of surgical research is not done by, nor in, countries with the greatest clinical need. Rather, research volume for surgery correlates with country gross domestic product (GDP). A bibliometric analysis found that of the 35 countries with the highest volumes of surgical research, high-income countries had the greatest presence at 85%, followed by upper middle-income countries with 12% and lower middle-income countries with 3%.[2] There were no low-income countries within the 35 countries with the highest research volumes. However, disease characteristics and subsequent research needs and findings from one region of the world are not necessarily transferable to another region, leading to a great unmet need for research to improve and advance the surgical care of people of all ages in many LMIC settings.

This problem of maldistribution of surgical research across different regions of the world is compounded by low volumes of research in surgery overall compared to its medical counterpart. Surgical research accounts for only 4.1% of all global health research activity, despite the fact that surgical conditions constitute one-third of the global burden of disease and surgical intervention is needed across all GBD subcategories.[12,13]

In order to better highlight the unique surgical needs faced by children in low-resource settings and to strengthen pediatric surgical research in LMICs, numerous efforts have been launched. For example, over the last decade, both the African Journal of Paediatric Surgery and the Annals of Pediatric Surgery were started and endorsed by the Pan-African Paediatric Surgical Association (PAPSA). The Journal of Pediatric Surgery, Pediatric Surgery International, and World Journal of Surgery have also progressively increased LMIC-specific pediatric surgical content in recent years. These journals allow pediatric surgeons in Africa and other LMIC regions to publish their results and highlight location-specific work and surgical needs. To create a common agenda for research, practice, education, and advocacy, the Global Paediatric Surgery Network launched a global collaborative in 2010 and published a roadmap of activities and future priorities in 2014.[14] Earlier this year, the first volume of DCP3 (published by the World Bank and funded by the Bill & Melinda Gates Foundation) included a chapter on congenital anomalies.[15] Finally, in 2012, Seminars in Pediatric Surgery brought together 23 pediatric surgeons from 9 different African countries to write and published a 10 paper issue on the challenges of pediatric surgical practice in Africa.[16] Now, 3 years later, they are bringing together another group of experts to look at pediatric surgery around the world.

Suggested research agenda for global pediatric surgery

To help address low research volumes and disparate areas of focus, both DCP3 and LCoGS outlined suggested research agendas for global surgery based on data and knowledge gaps identified during the course of their work.[2,17] Using information gleaned from a review of the literature on research for global pediatric surgery, we adapted these research agendas for a pediatric surgery focus. This eight-point agenda is described below and summarized in panel 2. As with the agendas from DCP3 and LCoGS, this pediatric surgery research agenda is intended to help guide and unify research focus, funding and priorities at a global level to maximize potential research gains and minimize "siloed" work. However, research priorities for an individual setting should be driven by local clinicians, researchers, and change agents, and should be modified to fit the local context and needs of children and families affected by surgical conditions.

Assessments of the global burden of surgical conditions in children in LMICs

Comprehensive countrywide data for the burden of surgical conditions in people of all age groups is lacking. Civil registration systems (birth and death certifications) are sparse with low-income countries reporting only 1% of deaths by cause.[18] Multinational household surveys such as UNICEF's Multiple Indicator Cluster Surveys (MICS), USAID's Demographic and Health Surveys (DHS), and the World Bank's Living Standards Measurement Study (LSMS) have very limited inclusion of questions about surgical conditions. Similarly, verbal autopsies and demographic surveillance surveys are not widely used for conditions needing surgical care.[2] Although several population-based assessments of surgical conditions have been completed and published by research groups,[19–24] their data are either not of adequate validity or of sufficient scope to be used for complete GBD calculations. Therefore, most global burden of disease estimates for surgical conditions are derived from hospital data or by modeling, which generates concerns regarding data accuracy and generalizability.[2,17]

This lack of data is further complicated by challenges of categorization. Most GBD data is reported by cause, not by intervention (such as surgery). Furthermore, as surgical conditions cross all disease subcategories and the need for surgical intervention varies by setting depending on disease patterns and the availability and timely use of medical care, simple estimates of the burden of pediatric surgical conditions are difficult.

Despite these challenges, data that do exist indicate a large burden of surgical conditions in children, and a high unmet need for surgical care. For example, 10.5% of children in Nepal were reported to have a surgical condition with 6.0% recounting unmet need for surgical care.[25] Data from 6 African countries found that 68.2% of adolescents reported at least one serious injury within the past year.[26] Finally, data from Uganda indicates that only 3.5% of the need for neonatal surgery is met by the health system.[27]

Avertable and non-avertable burden

Disease burden data provides the most information when they capture the full range of disability and mortality suffered by individuals with a disease, as well as the interventions used to address the disease. The burden of surgical conditions can be subdivided into two main categories: avertable burden and non-avertable burden. Avertable burden (conditions that can be prevented or corrected with surgical care) can be further divided into met need (averted DALYs) and unmet need (avertable DALYs)[28] (Figure 2). Non-avertable burden refers to conditions that cannot currently be averted with surgery, but which may be reduced with other interventions such as prevention or future surgical innovations.

Timeliness of intervention

Burden of disease (BoD) measures should (but do not currently) also capture death and disability suffered by children before they receive treatment, or the "delayed BoD". The disability a child suffers from living for years with an untreated surgical condition—such as compromised nutrition and development from an untreated cleft palate, social isolation from a stoma following partial treatment of Hirschsprung's disease, or mobility impairment from an untreated femur fracture—is substantial, and untreated pediatric surgical conditions are rampant. For example, it is estimated that there is a global backlog of up to 2.1 million cleft surgeries alone,[29] while the wait time in Kenya for a posterior sagittal anorectoplasty is 74 months and 72 months for an orchidopexy.[30] Even if treatment is finally received for these conditions, outcomes tend to be much worse for children receiving delayed care compared to those who receive timely intervention.[27,31]

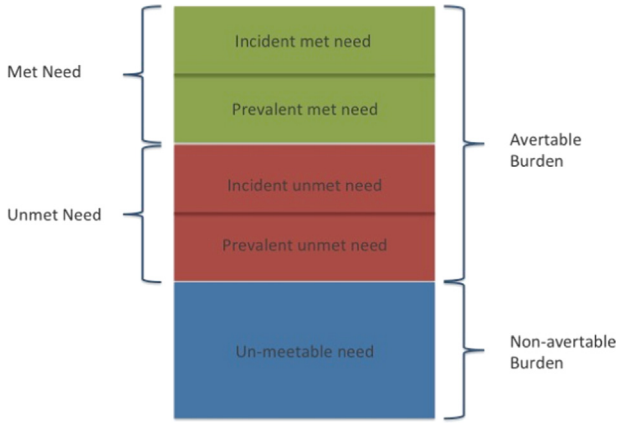

Fig. 2. Components of the burden of surgical disease. (Adapted with permission from Poenaru et al.[70]) Capturing the delayed burden of disease could be done by dividing the met and unmet need categories into an incident subsection (new cases), and a prevalent component (the backlog of children with a condition waiting for surgery).[30,70] Non-avertable burden refers to the burden that cannot be reduced with surgical care even in the best of circumstances.

Without robust data on the burden of surgical conditions in children, areas of greatest need are not known. This compromises planning of care delivery and prevention services, advocacy and allocation of resources, and assessment of effect of interventions. Global efforts by both countries and international agencies such as UNICEF and the WHO to reduce child mortality and improve child health can be greatly facilitated through understanding and monitoring of surgical conditions. Wide use of standardized and validated methods will allow for comparison and help ensure the accuracy of data collected.

Research is needed to develop, validate, and then use such methods for accurate reporting of the burden of surgical conditions in children, as well as interventions received. Methods that are sensitive enough to capture met need *and* unmet need, in addition to the timeliness of surgical care delivered, will be the most valuable in guiding policymakers and advocacy efforts. Accurate BoD estimates can then be used to guide greatly needed basic science, social science and clinical research into region-specific disease determinants, and, most importantly, to direct investments in resources required to reduce these disease burdens.

Strategies to address the non-avertable burden of surgical conditions in children in LMICs

DCP3 found that a large proportion of the burden of surgical conditions is currently non-avertable from scaling-up surgical care, meaning that there is a certain level of death and disability that we cannot avert at this time with a surgical intervention, even in the highest-resource settings.[17] For example, the death of a child who suffers massive head trauma may not be avertable even with the best of existing surgical care. Similarly, the death of a child who dies immediately at the scene of a motor vehicle collision from cardiac disruption is not avertable with surgical intervention. However, both of these deaths could potentially be addressed through injury prevention programs, and the death of the child with severe head trauma could in the future be prevented with new care delivery methods.

The majority of the non-avertable burden of surgical conditions in all age groups is due to injuries.[17] Injuries are a leading cause of

death and disability among children in all regions of the world.[32,33] However, reduction in injury-specific mortality rates over the last several decades has been small and has failed to realize similar improvements in mortality reduction seen with other leading causes of childhood death such as communicable diseases.[32,33] Research on how to best reduce this non-avertable burden of surgical conditions—including prevention strategies, improved care delivery methods, and surgical innovations for resource-limited settings—can help identify approaches to decrease child morbidity and mortality.

Strategies to address the avertable burden of surgical conditions in children in LMICs

One of the most pressing needs surrounding the surgical care of children in LMIC is identifying how surgical and anesthesia care can best be implemented in regions where needs are greatest but health systems are least developed. Implementation efforts can make the most impact when all dimensions of care delivery and all barriers a patient may face in receiving care are considered. Healthcare delivery requires *staff*, *stuff*, *space*, *and systems* (the 4Ss).[4] The presence of all these elements is necessary to avert delays in care which are associated with poor surgical outcomes.[34] Delays can be categorized into *delays in seeking care, delays in reaching care, and delays in receiving care.*[2]

There are many published examples of the deficiencies in components needed for pediatric surgery and anesthesia in many LMICs.[16,35–38] For example, a nationwide study of pediatric surgical care in Zambian hospitals found that minimum safety standards were met by only 14% of hospitals, and lack of surgical skill was the primary reason for referral for 72% of procedure types.[38] Consequences of such deficiencies—such as a large number of sick children, great backlog in cases resulting in advanced pathology, high mortality, and poor outcomes—are also common.[39,40] In contrast to the volume of literature assessing this capacity *problem*, studies looking at *solutions* are scarce; there are very few published examples of well-functioning surgical services for children in LMICs. Although optimal resources for children's surgical care to improve outcomes have been outlined for high-income countries (HICs),[41] these guidelines cannot practically be applied to many low-resource settings, and similar broad guidelines for LMICs do not exist.

Research is needed to define models of surgical care implementation for children that address all three delays in care, allow for rapid scale-up of services, and ensure equity and quality in care delivery. Such research could include assessments of basic platforms of care and packages of services that can be adapted to local contexts, implementation research into how the 4Ss can be expanded to meet needs including financing mechanisms that are practical and sustainable for low-income countries yet ensure financial risk protection for patients, quality measures of care delivered, and indicators to mark the functioning of services. Research must include but also go beyond the more common assessments of resource-appropriate "stuff" (e.g., low-cost anesthesia machines, power sources, and surgical instruments) to also include evaluation of systems (e.g., referral and transfer mechanisms), safety and quality measures of those systems, models to efficiently produce staff trained to care for children with surgical conditions, and methods to increase equitably distributed care delivery platforms. Solutions should be high quality, low cost, setting appropriate, and sustainable and should include strategies that address and prevent corruption.

In 2015, the 68th World Health Assembly called on member states to prioritize the provision of "quality, safe, effective, and affordable emergency and essential surgical care and anaesthesia services accessible to all who need them" as a necessary step "to achieve universal health coverage."[3] To fully respond to this call governments can develop implementation strategies and policies that are sensitive to the unique surgical needs of children. Further evidence is needed to guide such efforts.

Models for scale-up of the pediatric surgical workforce

There is a currently a large deficiency in absolute numbers and a maldistribution of the surgical workforce in many regions of the world. Recent estimates cite a shortage of over 1 million surgical, anesthetic and obstetric (SAO) providers across 136 LMICs.[2] In addition to a volume shortage of surgical providers, there is also a gross inequity in their distribution. Only 12% of the specialist surgical workforce works in Africa and Southeast Asia, which is home to 33% of the world's population.[2]

Existing data indicates that surgical and anesthetic providers trained in the care of children are even scarcer, with many countries having no providers at all (Table).[16,35–37] This deficit is especially pronounced in rural areas.[36] Some structured training programs in pediatric surgery do exist in LMICs, including options in India, South Africa, Egypt, and Nigeria. Both the West African College of Surgeons (WACS) and the College of Surgeons of East, Central and Southern Africa (COSECSA) have certification and training options. The Pan-African Association of Christian Surgeons, a faith-based organization, provides regional training of surgeons and anesthesiologists including fellowship-level pediatric surgical training and is recognized by COSECSA.[42] Across all LMICs, however, pediatric surgical and anesthesia training programs are quite limited in number, especially considering the current shortage of providers.[37]

Surgical training is both time and resource-intensive. Research is needed to help delineate strategies for efficient augmentation of the pediatric surgical workforce in low-resource settings, as well as retention tactics for trained providers. Studies are needed to assess best educational methods in LMICs including curriculum components, region-specific case volume and scope requirements to ensure proficiency, and utility of training partnerships (regional, national, LMIC–LMIC, HIC-LMIC, NGO, etc.). Assessments of the training and use of pediatric surgical provider types are also needed. To rapidly meet current population needs for pediatric surgery, methods such as task sharing may be useful as fully

Table
Pediatric surgeon numbers around the world.

Country	Pediatric surgeons	Source
Andorra	0	Andorra ministry of helth
Bahrain	4	Kingodom of Bahrain Minsitry of Health
Botswana	2	Botswana ministry of health
Brazil	1245	Brazilian Medical Demography, Federal Council of Medicin
Cape Verde	0	Relatório estatístico 2011, Ministry of Health
Central African Republic	2	Système Nationale d'Information de Santè; Sassara Sarl et ACESS Sarl
Cuba	229	Anuario Estadistico De Salud 2013
Cyprus	8	Statistical Service of Cyprus, Health and Hospital Statistics
Djibouti	0	Djibouti Ministry of Health
Ethiopia	4	COSECSA
Kenya	9	COSECSA
Malawi	1	COSECSA
Mozambique	2	COSECSA
Rawanda	1	COSECSA
Uganda	4	COSECSA
Zambia	4	COSECSA
Zimbawe	2	COSECSA

*Data from the WHO Global Surgical Workforce Database.[71]

trained pediatric surgeons will not be available to most children in the immediate future. Comparative studies of the outcome and local impact of different models of training can help ensure quality and guide future improvement efforts. In addition, development of evidence-based guidelines for standards of training, measures to assess competency of care providers, and accreditation standards for training programs can help improve the quality of providers.

Investigation is also needed to guide retention and equitable distribution of pediatric surgical care providers. A number of strategies have been suggested to improve distribution and retention of medical providers, including increased training options through improved supervision and continuing professional development (CPD), loan repayment, bonding, student exposure to rural areas, and service requirements.[2] However, robust evidence to support and guide these suggestions is limited. Recent increased connectivity (such as through wifi availability) makes educational support easier, facilitating opportunities for pediatric surgical organizations to provide ongoing education for members. However, additional research is needed to further guide exactly what methods can prevent loss of pediatric surgical providers due to flight to urban centers, migration to other countries and provider burnout.

Research regarding education and retention of pediatric surgical care providers should exist across all levels of the health systems (from the community to tertiary and specialized hospitals), and should encompass different levels of care providers (from community health workers to nurses to specialty surgeons). Educating healthcare workers at and across all levels can help both with timely treatment as well as with prevention, and may potentially alleviate some of the burden seen at more advanced care facilities.

Critical evaluation of partnerships

Many aspects of surgical care can be facilitated through effective use of partnerships, including those with non-governmental organizations (NGOs), academic institutions, funding partners, and the private sector. Although such partnerships are common, they are not all effective in addressing a region's most pressing needs, improving health, or increasing local ability to deliver care. In addition, data on their efforts and outcomes are frequently lacking.

For example, there are over 300 non-governmental organizations (NGOs) that deliver surgical care in LMICs.[43] Charitable platforms used by these groups include short-term surgical missions, self-contained mobile surgical units, and permanent NGO-run specialty hospitals.[44] Their work can be invaluable, especially where other surgical options do not exist. However, NGO efforts are sometimes isolated, existing outside of government systems and uncoordinated with that of other NGOs, thus failing to contribute to sustainable system improvements (even in settings where such improvements are feasible). In addition, specialized charitable platforms that treat only a limited number of conditions often lack the capacity to treat emergencies (such as injuries) that impose the greatest burden on children. In some situations they may actually consume the limited local human and physical resources that do exist, further compromising the capacity to address emergent conditions. However in general, little is known about the total surgical volume charitable platforms provide,[45] nor the costs, quality, safety, and system impacts of such care.[44]

Private–public partnerships are another strategy to facilitate surgical care delivery for children. An estimated 80% of general pediatric surgical cases in Africa are done in the private sector.[16] Although private sector engagement in healthcare delivery in LMICs is controversial, examples exist in which the private sector has been contracted to manage hospital facilities for the public sector in order to provide greater coverage than what would have been possible with government resources alone.[46] However, regulatory mechanisms for private providers are often weak, making it challenging to assure quality service delivery and to coordinate with other state actors. Evidence to guide successful private–public partnerships is limited.[47]

Inter-country partnerships can be another tool to improve surgical care in low-resource settings, especially through educational initiatives. Some of the most valuable partnerships may be through LMIC–LMIC collaborations. For example, CURE Hydrocephalus, now under the direction of Dr. John Mugamba, a Ugandan-born and South African fellowship-trained neurosurgeon, has trained 24 surgeons in the surgical treatment of children with hydrocephalus, resulting in 14,000 lives saved.[48,49] And PAPSA, formally established in Nairobi in 1994, provides a number of research, care delivery, and education opportunities to strengthen pediatric surgery in Africa. HIC–LIC partnerships can also provide a range of services through direct care delivery, training and education, and systems building, and there is a large and growing interest in global surgical work amongst pediatric surgeons in HICs.[50] However, the most common form of global health involvement for HIC surgical providers and academic institutions is still the short-term surgical "mission." During these trips, there is risk for local providers to be excluded from the operating room, local systems to be left resource depleted, operative patients to be lost to follow-up, and transparent evaluations of service provision and outcomes to fall by the wayside if care is not taken to incorporate local care providers and the most pressing needs of the local systems.

Although we only delineated several partnership types in this document, research is needed to better define how all partnerships—whether they be with HIC partners, LIC leaders, NGOs, different care delivery sectors, researchers or funding organizations—can best help meet local needs and strengthen surgical systems and care delivery efforts. Investigation is needed into what current partnerships are doing, factors that enables fruitful partnerships, outcomes and impacts of existing partnerships on children and local health systems, and methods to guide coordination and regulation of partnership efforts.

Tools for incorporating and measuring surgical care as a basic component of health systems

Over the past two decades, global health has focused primarily on individual diseases. As a result, the majority of global health efforts, such as those surrounding the MDGs, have also focused more narrowly on addressing and tracking single diseases or health measures for select populations. This has facilitated remarkable reductions in death and disability from certain conditions, but such gains have not been mirrored by similar improvements to health systems, integration of services, hospital-based care, or health equity.

Widespread provision of surgical services can help strengthen health systems and therefore delivery of a broad spectrum of medical services. In January 2014, President of the World Bank, Dr. Jim Yong Kim,[51] called surgery "an indivisible, indispensable part of health care." The 68th World Health Assembly declared that "the sustainable provision of emergency and essential surgical care and anaesthesia is a critical part of integrated primary health care."[3] Because of its complexity, delivery of safe surgery and anesthesia signals the presence of the necessary resources of a responsive health system capable of providing not only surgical care, but also of addressing a broad range of health challenges whether it be a child in sickle cell crisis or a mother dying from

obstructed labor.[52] However, as the global community has not largely prioritized surgical care, its provision is absent or weak in many health systems and surgical conditions and surgical treatments are not included within standard health facility and health system measurement tools, compromising efforts to improve not only surgical care, but also wider health system strengthening efforts.

Research is first needed to assess how essential surgical and anesthesia care can best be incorporated into all levels of the health system (from community centers to tertiary hospitals) as a tool for general health system strengthening. Implementation was discussed in more detail above, and such implementation efforts should be done with a broader view of strengthening not only surgical care, but also health system capacity. Implementation should go hand in hand with development of efficient, standardized and validated measures of surgical care that can be used at national and international levels to help signal wider health system performance. These measures should assess not only structural components such as physical and human resources, but also process and outcome elements for both children and adults. Such tools may serve the dual purpose of facilitating the integration of surgery within national health systems, and simultaneously provide a mechanism for measuring, comparing and subsequently improving healthcare performance.

These data can inform indicators of surgical and anesthesia care for children within health systems, such as those suggested by LCoGS.[2] Such indicators can be used by global health and development agencies in their monitoring protocols, such as the World Bank's World Development Indicators,[53] the new Global Reference List of 100 Core Health Indicators,[54] and indicators for the SDGs[55] to help ensure progress towards wider health and development improvements.

Methods for assessing the human, financial and economic impact of surgical conditions and surgical care

Disability adjusted life years (DALYs) are currently the standard measure for assessing the global burden of disease. DALYs include both mortality and morbidity components by combining years of life lost (YLL) due to premature mortality with years lost due to disability for individuals living with a disease.[56]

However, the DALY-based approach to estimating the GBD has been criticized for having many limitations including subjectivity, comparability, oversimplification, practicality and interpretation.[57] In addition, DALYs tend to be condition- rather than treatment-based, limiting their utility for monitoring the impact of surgical interventions. Finally, DALYs are a measure of death and disability solely of the individual affected by them. They fail to capture other critical areas of illness impact including [1] the physical, psychological, and financial impact on families caring for a sick child[2]; the financial impact on households or individuals seeking surgical care, which recent estimates have found to be immense[2,3,58]; and the economic impact on societies due to lost productivity resulting from untreated surgical conditions, which has been predicted to reduce annual GDP growth as much as 2% if not addressed.[2,5] The inability of DALY-based disease burden estimates to fully or accurately delineate the impact of surgical conditions limits their utility in guiding policy decisions and resource allocations.

New global commitments to UHC include SDG target 3.8 of achieving universal health coverage,[55] and the WHO/World Bank targets of 80% coverage of essential health services and 100% financial risk protection from catastrophic and impoverishing health payments.[59] Current estimates suggest that surgical conditions represent approximately 30% of the global burden of disease.[60] Children comprise nearly half of the population in the least developed regions of the world,[6] and 47% of people living in extreme poverty are 18-year old or younger.[61] Therefore, meeting these new global promises will not be possible without addressing the burden of surgical conditions in children. To do this, research is needed to identify standardized measures that are simple to collect, easy to understand and apply, and more fully capture the health, welfare, and economic impacts of surgical conditions and interventions on children, their families, and the countries in which they live. Such information can strengthen advocacy efforts to support much needed implementation efforts, as well as identify needs and solutions for improved surgical and anesthesia care.

Aligning pediatric surgical care with other global health and development endeavors

Access to surgical and anesthesia care can help alleviate death and disability from numerous conditions and is a necessity for good population health. Surgical services are needed across all GBD subcategories,[13] throughout the course of life (from birth to death) and within all levels of care (prevention to palliation).[62] Surgery's integral and cross-cutting nature means that incorporating it into the priorities, delivery plans and monitoring mechanisms of other areas of global health focus can help realize improved outcomes across many different sectors. However, data is needed on how these diverse global health movements can best work together to promote maximal improvements in the health of children.

Improving access to surgical care for children can help realize improvements for other areas of global health focus, including maternal, newborn, and child health (MNCH), infectious disease, and injuries. The MNCH movement was born out of a philosophy that similar vulnerabilities existed between the three groups, and that common interventions could improve health across these populations.[63] Surgical intervention can similarly improve the health of these populations. For example, intrapartum-related events are one of the leading global causes of child death,[32] and it is estimated that increased access to cesarean delivery could reduce neonatal mortality by 30–70%. [64] Another leading cause of child mortality is injury. Although not every injured child will need a surgical procedure, he or she will benefit from the skills of a surgically trained provider. Finally, despite great improvements in mortality from infectious disease across people of all age ranges over the last two decades, communicable disease remains the leading cause of death of children across the globe. Delays in medical care frequently lead to pathologies (empyema, osteomyelitis, intestinal perforation and obstruction, hepatic and brain abscesses, rheumatic heart disease, and soft tissues infections to name a few) necessitating surgical intervention.

Similarly, widespread access to surgical care for children can also help realize the new larger global health and development goals, including commitments to UHC with financial risk protection, and a collection of SDGs aimed at ending poverty, promoting economic growth, and ensuring health and well-being for all. Surgical care for children is compulsory to reach the single health-related SDG (ensure healthy lives and promote well-being for all at all ages by 2030),[55] and the two World Bank targets for UHC (80% essential health services coverage and 100% financial protection from out-of-pocket payments for health services by 2030).[65] Research on how to affordably scale-up quality surgical care for children in an equitable manner to help meet population needs and subsequently realize these goals is needed. Similarly, evidence on how to provide such care in a manner that prevents impoverishment and catastrophic expense for surgical patients is critical. For example, policies addressing coverage of adult surgical care

have been studied using extended cost-effectiveness analysis (ECEA), revealing that the provision of "free care" may paradoxically increase impoverishment among the poorest patients.[66] In children, provision of free care in Sierra Leone led to a 500% increase in surgical volume at one hospital.[67] However, little is known about the financial impacts of such care on families. Applying ECEA methodology to pediatric surgical care may provide insights influencing the manner in which pediatric surgery is included in basic packages of UHC.

Further research exploring the synergies between surgery and other global health movements and priorities can lead to better understanding of mechanisms influencing health, welfare and development, as well as opportunities for cooperative strategies and joint improvements.

Considerations for evaluators and partners of potential global pediatric surgery research projects

Research has great potential to generate findings that can ultimately lead to improved patient health and welfare. However, if not conducted judiciously, there is also potential for harm. The Lancet Commission on Global Surgery presented a series of questions for implementers, funders, editors and ethics committees to consider (in addition to the academic merit of the proposal) when evaluating potential global surgery projects. These considerations were developed from discussions with academic and clinical leaders in all branches of surgery from countries included within COSECSA. These factors, presented in the form of questions, are reprinted in Panel 2. They can be tailored as needed to fit the cultural environment of the setting in which they are being used, and can help evaluators assess the appropriateness, ethical elements and potential benefits and harms of future global pediatric surgery research projects.

Similar topics should also be considered by groups engaging in research at sites outside of their home institutions. Research priorities of local clinical providers or policymakers should take precedence and local teams should have the opportunity to fully participate in research ventures to help ensure that questions of greatest need are investigated and outcomes and interventions are relevant to the populations being studied. Locally driven, locally vested research may also maximize research impact, as LMIC researchers may be better able to leverage relationships at facility and national levels to effect policy change. Under these settings, pediatric surgeons in sub-Saharan Africa have demonstrated a high level of academic productivity and success.[34] In places where centers for pediatric surgical research have not yet been established, both HIC-LMIC and LMIC–LMIC partnerships can help to build capacity, especially if an accompaniment approach is used. Long-standing relationships with local partners can help facilitate these interactions.

Research availability, use, and dissemination

Lack of pediatric surgical research in LMICs is compounded by poor accessibility of research that does exist, and limited dissemination of research findings. Both accessing as well as publishing research articles often requires money, English fluency, and electronic access. This complicates the ability of many professionals in LMICs to access relevant articles, as well as publish their own research. Examples of options and attempts to address these access issues include open access journals, journals that offer free access depending on IP address location, HINARI, electronic information for libraries (eIFL), INASP, African Journals Online (AJOL), and the WHO Global Health Library. However, ensuring that all pediatric surgical researchers and readers in LMICs are able to access current research, as well as publish their own papers, will require widespread consideration of current barriers by those involved in research creation, publication and dissemination.

Ensuring that information is made available to the public about pediatric surgical care and conditions is also critical, particularly for advocacy efforts. Mobilization of patient groups to advocate for certain basic rights to medical care has been instrumental to the success of prior global health endeavors, such as efforts to control the HIV/AIDS epidemic. However, similar patient advocacy groups are lacking in surgery, and this is in part due to a lack of knowledge and understanding about the problem. Work must be done to inform the public about the current state of surgical care for children, as well as the impact of delayed or absent care on children, families and communities. In addition, care must be taken to depict areas of greatest need. Not all conditions have the same "cosmetic appeal" to, or understanding from, the public. For example, it may be difficult to communicate the life-changing impact of an anorectal malformation repair compared to the easily relatable smile of a child with a repaired cleft lip. However, support must be garnered and equitably distributed for all essential surgical needs. Clear presentation and dissemination of research findings can help build support from policymakers, funders, and the public.

Conclusion

At the heart of global pediatric surgery research is a desire that no child should suffer the consequences of surgical conditions for which effective treatments can be provided. Improved understanding of the epidemiology of pediatric surgical disease; its impact on individuals, families, communities, and countries; the availability and accessibility of safe surgical and anesthesia care; the comparative effectiveness of models for scaling-up surgical care; the economic consequences of inaction; and the complementarity between surgical care, health system strengthening and other global health movements are all critical to this agenda. Armed with this knowledge, clinicians and policymakers can help make the provision of safe surgical and anesthesia care a priority on both national and global levels and subsequently improve the well-being of billions of children.

Action points and opportunities for national and international partners to improve global pediatric surgical research

- An increase in research capacity, training, funding and output in LMICs should be a priority on both local and global levels. Partners with advanced research abilities and experience can support the development of research capacity in LMICs through locally driven, locally vested partnerships. Both HIC-LMIC and LMIC–LMIC relationships can effectively build capacity, especially if an accompaniment approach is used.
- Those involved with the publication of research—including journals, journal editors, researchers and funders—should consider options that will allow care providers, researchers and policymakers in LMICs to access and publish research without financial, physical or linguistic constraints.
- Pediatric surgical research efforts on a global scale can focus on areas with large knowledge gaps including assessments of the public health impact of pediatric surgical care; the global burden of surgical conditions; strategies to address the non-avertable burden of surgical conditions; tools for measuring surgical care within health systems; models of surgical care

implementation; partnerships; methods for scale-up of the surgical workforce; and aligning pediatric surgical care with other global health endeavors.
- Funders, editors, and ethical committees can consider a list of core questions when reviewing global surgery research projects to help maximize potential benefits and minimize harms
- Global health and development agencies such as the WHO, USAID, World Bank and UNICEF who are involved in population- and facility-based data collection can help augment data for health improvements by including validated questions regarding surgical conditions and surgical care of children in their data collection efforts.

Panel 1. Definitions

Global surgery: An area of study, research, practice, and advocacy that seeks to improve health outcomes and achieve health equity for all people who need surgical and anesthesia care, with a special emphasis on underserved populations and populations in crisis. It uses collaborative, cross-sectoral, and transnational approaches and is a synthesis of population-based strategies with individual surgical and anesthesia care.[68]

Surgical condition: Any disease, illness, or injury in which surgical care can potentially improve the outcome.[2,17]

Surgical care: The provision of operative, perioperative, and non-operative management; anesthesia; and obstetric care for all surgical conditions.[2]

Surgical procedure: The suturing, incision, excision, or manipulation of tissue; or other invasive procedure that usually requires local, regional, or general anesthesia.[69]

Panel 2. Suggested global pediatric surgery research agenda

1. Assessments of the global burden of surgical conditions in children in LMICs
   - Development of validated tools for population-based assessments of the burden of pediatric surgical conditions
   - Population- and facility-based data collection and analysis to determine the met and unmet need for pediatric surgical care. This would ideally be done using existing household data collection methods (civil registration, verbal autopsy, population surveys such as MICS, DHS, LSMS) and facility assessments (WHO SARA, HAT, SAT) and would include timeliness of surgical intervention and the care provided
2. Strategies to address the non-avertable burden of surgical conditions in children in LMICs
   - Development, implementation, and assessment of approaches to reduce the non-avertable burden of surgical conditions, including prevention strategies, improved care delivery methods, and surgical innovations for resource-limited settings
3. Strategies to address the avertable burden of surgical conditions in children in LMICs
   - Implementation science to determine how individuals, organizations, and nations can practically bring together the staff, stuff, space, and systems required for equitable delivery of safe and affordable surgical care for children
   - Research delineating feasible minimum resource needs for safe pediatric surgical care in low-resource settings
   - Research identifying sustainable financing mechanisms for surgical and anesthesia care for children that are feasible for countries and affordable for patients
   - Analysis of best indicators of the scope, quality and safety of surgical and anesthesia care provided for children
4. Models for scale-up of the pediatric surgical workforce
   - Comparative studies of training models for scale-up of the pediatric surgical and anesthesia workforce, as well as program outcomes
   - Studies of outcomes following pediatric surgical care delivered by task-sharers (including general surgeons performing pediatric surgery)
   - Establishment of evidence-based standards to guide training and licensing of providers and accreditation of programs
   - Research into strategies for continuing medical education and best practices for retaining pediatric surgical providers in LMICs and in rural areas
5. Critical evaluation of partnerships
   - Investigation into what is being done by partners, how those efforts align with local needs, how they impact the population and health systems of the areas in which they work, and outcomes of services provided
   - Assessment of factors that lead to successful partnership and mechanisms to facilitate those relationships to help maximize sustainable health and welfare gains surrounding the surgical care of children
6. Tools for measuring and incorporating surgical care as a basic component of health systems
   - Research on how surgical and anesthesia services can be incorporated into all levels of the health system to maximize improvements not only to surgical care, but to broader health system strengthening efforts
   - Development of standardized and validated measures of surgical care that can also be used at national and international levels to signal wider health system performance
   - Development of pediatric-specific health systems indicators and targets to track delivery of surgical and anesthesia care for children
7. Methods for assessing the human, financial economic impact of pediatric surgical conditions and surgical care
   - Development of practical methods to assess the human, financial and economic impact of surgical conditions, and surgical interventions on children, their families and the countries in which they live
8. Aligning pediatric surgical care with other global health and development endeavors
   - Investigation regarding how diverse global health movements can best work together to promote maximal improvements in the health of children
   - Further research establishing the relationship and synergies between delivery of pediatric surgical services and broader health and development goals including universal health coverage, health system strengthening, financial risk protection and poverty alleviation for families, health outcomes for children, and economic productivity of countries. Such information may generate a better understanding of mechanisms influencing health, welfare and development, as well as opportunities for cooperative strategies and joint improvements

Panel 3. Considerations for implementers, funders, editors, and ethics committees when evaluating possible global surgery research projects

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Appropriateness: Does the project promote appropriate interventions or applications for the region? If it merely assesses the uptake of a non-supportable technique from a different setting, then this might be very much in doubt. If it uses techniques that can easily be replicated in the country for which they are being proposed, it might be appropriate.

Ownership: Is evidence of local initiation and ownership of the project available? The most desirable ventures are those initiated by and led by local teams.

Authorship: Are authors from the country where the work was (or is proposed) to be done, or are they from other countries? Projects should be done by or, at minimum, involve local researchers.

Local capacity building: Does the research build local research capacity? If all discussion and analysis is done outside of the country, then the answer might be no. Evidence of improved capacity for further research after project completion should be available.

Consent: Has consent been appropriately obtained (if it is culturally appropriate in the particular situation)? Potential research participants might find it difficult to say no to participation in any surgical study owing to possible power dynamics and fear that refusal could lead to denial of care. Participants should be given a clear opportunity to discuss the study, and should realize their treatment is not dependent on study participation.

Treating identified conditions: What happens when pathological abnormalities are identified? Research studies might identify disease that the research team is unable to treat both in research participants and in their accompanying family. What should the research team do about this? If a disorder is diagnosed during the course of a research project, a plan to facilitate appropriate treatment should be in place.

Quality: Is the project good science? If not, then it should be rejected, with clear reasons and suggestions for how to improve the next submission.

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