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ORIGINAL ARTICLE

Pediatric surgery backlog at a Ugandan tertiary care facility: COVID-19 makes a chronic problem acutely worse

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Abstract

Background 1.7 billion of the world's 2.2 billion children do not have access to surgical care. COVID-19 acutely exacerbated this problem; delaying or preventing presentation and access to surgical care globally. We sought to quantify the effect of COVID-19 on children requiring surgery in Uganda.

Methods Average monthly incident, elective pediatric surgical patient volume was calculated by sampling clinic logs before and during the pandemic, and case volume was quantified by reviewing operative logbooks for all surgeries in 2020 at Mulago Hospital, Kampala. Disability-Adjusted Life Years (DALYs) resulting from untreated disease were calculated and used to estimate economic impact using three different models.

Results Expected elective pediatric surgery cases were 956. In 2020, pediatric surgery at Mulago was limited to 46 elective cases, approximately 5% of the expected incident cases, leading to a backlog of 910 patients and a loss of 10,620.12 DALYs. The economic impact of more than 10,000 disability years in Uganda is conservatively estimated at $23 million USD with other measures estimating ~ $120 million USD.

Conclusion The COVID-19 pandemic limited access to pediatric surgery in Uganda, making a chronic problem acutely worse, with costly consequences for the children and health system.

Keywords Surgical backlog · COVID-19 · DALY · Economic impact · Uganda · Pediatric · Surgery

Introduction

The burden of pediatric surgical disease in low- and middle-income countries (LMICs) is staggering; 1.7 billion of the world's 2.2 billion children do not have access to surgical care. Travel, out-of-pocket expenditure, a paucity of pediatric surgical providers, and limited access to operating theaters all contribute to the problem.

Each of these problems contribute to limited access to pediatric surgery in Uganda prior to the COVID-19 pandemic. At the time of this paper 7 COSECSA-certified pediatric surgeons in 2 centers provided care for Uganda's 20 million children [1]. Two large referral hospitals in Northern (Lacor in Gulu) and Eastern Uganda (Soroti) do not have pediatric surgeons at their hospital systems and are 291 km and 334 km away from Kampala, approximately a 6- to 10-h travel time between the cities. [1] In a 2016 study of the burden of pediatric surgical conditions, 14% of children in Uganda have had a surgical condition and only half of these children have received treatment for their condition; this

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means 1.3 million children have a current need for surgical care, resulting in a growing backlog of necessary procedures [2].

The lack of resources for elective cases in Uganda has created an emergency surgery paradigm. In a study published in 2020, emergency procedures utilized 50% of the pediatric surgical capacity across the 2 major referral hospitals in Uganda. The proportion of colorectal congenital cases that were delayed due to emergency procedures was ~ 50%, 30% of inguinal hernias across both hospitals were incarcerated or strangulated at time of presentation, and 40% of all inguinal hernia admissions at Mulago were delayed [3]. In a similar study at Mulago Hospital in Kampala, more children presented with an incarcerated or strangulated hernia ($n = 40$) than a non-incarcerated hernia ($n = 37$) meaning 50% of children at the national referral hospital do not get their inguinal hernias repaired unless the procedure becomes an emergency [3]. Data from high-income countries suggest that ~ 5% to 10% of inguinal hernia repairs in children are incarcerated at time of repair [4].

COVID-19 dramatically altered the fragile surgical ecosystem that did exist in Uganda. On April 18, 2020 the WHO released two technical guidance reports, recommending health systems 'progressively postpone all but the most urgent elective surgery and internally repurpose space and staff to COVID-19'[5]. Optimization of which procedures, when, and how to minimize health risks for cases that are urgent or emergent, however, were not well defined [7]. Physicians practicing in LICs were less likely to have received guidance on children's elective surgery compared with lower and upper middle-income countries [6]. Although providers of children's surgery were generally in agreement that there needed to be cancellation or delay of elective surgical cases, there was no consensus on which procedures should fall under this umbrella [7]. Recently published data from the COVIDSurg collaborative revealed that LMICs will bear the brunt of the estimated 28 million surgical operations cancelled [7]. COVIDSurg projected the backlog to take almost a year to clear if surgeons worked at 120% capacity; however, LMICs already have baseline fragilities in service provision that hinder function at supernormal capacity [8]. Furthermore, these projections were made prior to the COVID surge occurring in Uganda and many other LMICs in June, July, and August 2021 and are likely an underestimate.

COVID-19 acutely exacerbated the burden of surgical disease worldwide as travel restrictions prevented non-emergent travel, hospitals stopped elective cases, and a combination of public fear and restricted service meant many urgent and emergent cases presented late or not at all. In this study we examine the impact of COVID-19 on elective pediatric surgical case volume at Mulago National Referral Hospital in Kampala, Uganda, calculating the long-term effect through Disability-Adjusted Life Years (DALYs) and economic impact of untreated pediatric surgical conditions.

In this study we sought to quantify the impact of COVID-19 on elective pediatric surgical cases at the Mulago National Referral Hospital (MNRH) in Kampala, Uganda by examining clinic and operative volume before and during the pandemic and determining the economic impact of the limitations in access to surgery.

Materials and methods

To determine the number of patients waiting for surgery, we sampled the pediatric surgery casebook, a record of patients seen and diagnosed with surgical conditions in the weekly outpatient clinic at MNRH. Patients with diagnoses that required surgery, but who had not yet accessed surgical care, were sampled for 5 different months (January, February, and May 2018, February 2019, and September 2020). We chose 4 months before the pandemic and one from the COVID era (September 2020) with data from 4 weeks of clinic. When looking at the months before and during the pandemic, a convenience sample of months with complete records was used. The five months included in this analysis were chosen because those were months that had no canceled clinics or missing records of clinics, which we thought would give the most robust sample and comparison between the pre-COVID and COVID era. Patients who were able to access surgical procedures were subtracted from the backlog estimate.

The mean monthly incident case load presenting to the clinic was categorized into four categories: complex pediatric general surgery (e.g., pull through for Hirschsprung's Disease), complex pediatric urology (e.g., hypospadias repair), regular pediatric general surgery (e.g., colostomy closure, umbilical hernia repair), and a separate category for inguinal hernias, hydroceles, and undescended testes (HH&UT). Operating theater logs were used to determine elective case volume.

A Disability-Adjusted Life Year (DALY) represents the loss of one year of full health. DALYs rely on disability weights (DW) which represent the magnitude of health loss associated with a particular outcome, an area of ongoing work in pediatric surgical conditions [9]. Disability weights are measured on a scale from 0 to 1, where 0 equals full health and 1 equals death [10].

In this particular data set, elective cases were grouped into categories rather than individual diagnoses. Given the groupings of disease we elected to assign a Disability Weight (DW) to each group based on the most conservative measure for a category. For example DWs for Complex General Surgery ranged from 0.72 to 1, so we used 0.72 to estimate the impact of this paucity of care.

Patient age was estimated using the Surgeons OverSeas Assessment of Surgical Need (SOSAS) survey [2]. SOSAS interviewed a random sample of 4248 individuals in 2315 households in 105 randomly selected clusters throughout Uganda. 2176 of those individuals were aged 18 or less and of those pediatric respondents the median age was 6.1 [2].

DALY = (DW × Number of Cases) × (Life Expectancy − Age of Person),

Life Expectancy in Uganda in 2019 = 63.37 years,

Age of Person = 6.1 years.

Below are examples of comparable DWs based on disease category. The pathology and its corresponding DW in bold were used to calculate DALYs lost.

Complex general surgery

Disease	Disability weight
Gastroschisis [11]	1
Intestinal atresia NOS [12]	0.87
Esophageal atresia with tracheoesophageal fistula [13]	0.85
Hirschsprung disease [14]	0.72

DALYs Lost = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$5956.10 = (0.72 \times 144) \times (63.37 - 6.1)$.

Complex urology

Disease	Disability weight
Posterior urethral valve [15]	0.571
Bladder exstrophy [15]	0.342
Testicular torsion [15]	0.324
Severe hypospadias [14]	0.275

DALYs Lost = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$859.05 = (0.275 \times 54) \times (63.37 - 6.1)$.

Regular general

Disease	Disability weight
Disability weights not available for other diagnoses in this category	
Umbilical or epigastric hernia [16]	0.1

DALYs Lost = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$1317.21 = (0.1 \times 230) \times (63.37 - 6.1)$.

Hernias, hydroceles, and undescended testes

Disease	Disability weight
Undescended testis [12]	0.22
Hydrocele [16]	0.1
Inguinal or scrotal hernia (unilateral or bilateral) [16]	0.1

DALYs Lost = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$3023.86 = (0.1 \times 528) \times (63.37 - 6.1)$.

DALYs lost

5956.10 for Complex General + 859.05 for Complex Urology + 1317.21 for Regular General + 3023.86 for HHUT = 11,156.22 DALYs lost.

46 cases, however, were performed. Since we do not have the data on what kind of cases were performed, we can estimate how many of each case was done using the case type percentage of the overall amount in the log books for 2020.

Complex general

144/956 = 15%,

15% × 46 = 6.9 cases,

DALYs Averted = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$286.35 = (0.72 \times 6.9) \times (63.37 - 6.1)$.

Complex urology

54/956 = 5.6%,

5.6% × 46 = 2.59 cases,

DA TextBreak="Yes"LYs Averted = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$40.66 = (0.275 \times 2.59) \times (63.37 - 6.1)$.

Regular general

230/956 = 24%,

24% × 46 = 11.10 cases,

DALYs Averted = (DW × Number of Cases) × (Life Expectancy − Age of Person),

$63.57 = (0.1 \times 11.10)$ x (63.37—6.1).

HHUT

528/956 = 55%,

55% × 46 = 25.41 cases,

DALYs Averted = (DW × Number of Cases) × (Life Expectancy − Age of Person),

145.52 = (0.096 × 25.41) × (63.37 − 6.1).

Total DALYs averted

286.35 for Complex General + 40.66 for Complex Urology + 63.57 for Regular General + 145.52 for HHUT = 536.10.

DALYs lost after DALYs averted accounted for

11,156.22 − 536.10 = 10,620.12.

Different models exist for translating DALY amounts into monetary values. We compare three different models not to argue the validity of one versus the other but rather to demonstrate the significant economic impact these unperformed surgeries have on the economy regardless of what model is used: Gross National Income (GNI) Atlas, GNI purchasing power parity (PPP), and the Value of a Statistical Life Year (VSLY).

In order to compare economic statistics across countries, the data must first be converted into a common currency using a country-specific conversion factor.

The World Bank's official estimates of the size of economies are based on GNI converted to current U.S. dollars using the World Bank Atlas method. The Atlas method smoothes exchange rate fluctuations by using a three year moving average, price-adjusted conversion factor [17].

Unlike market exchange rates, PPP rates of exchange allow this conversion to take account of price differences between countries. In that way GNI PPP reflects people's living standards comparably across countries. In theory, 1 PPP dollar (or international dollar) has the same purchasing power in the domestic economy of a country as $1 (USD) has in the US economy [18].

The VSL is the marginal rate of substitution between income and risk of death. It is often measured as an individual's willingness to pay for a small change in their risk of dying over a defined period, scaled up to a 100% risk to represent 1 statistical life [19]. The VSLY is the marginal rate of substitution between income and life expectancy, or the annualized VSL, and is typically measured as the total VSL divided by discounted future life-years remaining [20]. VSLY = VSL/Life Expectancy, In Uganda = 700,000/63.37 [21].

Each of these methods multiplies a country-specific figure—GNI Atlas 2019, GNI PPP 2019, and VSLY—by the DALY amount in order to estimate a monetary value [21–24].

Results

Pediatric procedure type	Mean incident (non-emergent) cases per month	Yearly case burden based on median incident volume	Case burden extrapolated over 5 years
Complex general	12 (15.1%)	12 × 12 = 144	144 × 5 = 720
Complex urology	4.5 (5.6%)	4.5 × 12 = 54	54 × 5 = 269
Regular general	19.2 (24.1%)	19.2 × 12 = 230	230 × 5 = 1152
Hernias, hydroceles, and undescended testes	44 (55.2%)	44 × 12 = 528	528 × 5 = 2640
		Total = 956	Total = 4781

The estimated incident elective pediatric surgical patients at Mulago was 956 patients in 2020. In 2020, pediatric surgery at Mulago was limited to just 46 elective cases, approximately 5% of the expected incident cases for the year.

DALYs lost

5956.10 for Complex General + 859.05 for Complex Urology + 1317.21 for Regular General + 3023.86 for HHUT = 11,156.22 DALYs lost.

Total DALYs averted

286.35 for Complex General + 40.66 for Complex Urology + 63.57 for Regular General + 145.52 for HHUT = 536.10.

DALYs lost after DALYs averted accounted for

11,156.22 − 536.10 = 10,620.12.

More than ten thousand years of disability were lost due to unperformed elective pediatric procedures at Mulago hospital alone in 2020. This is a staggering number of lives lost or years lived with disability. This significant burden does not just weigh on the health of the nation but also on its economy. Below are the economic impact estimates using the GNI, ATLAS, and VSLY methods.

- GNI $\$2220 \times 10620.12 = \$23,576,666.40$ USD,
- ATLAS $\$11,553.385 \times 10620.12 = \$122,698,335.19$ USD,
- VSLY $\$11,046.24 \times 10620.12 = \$117,312,394.30$ USD.

Discussion

Given the estimated number of elective pediatric surgical patients presenting annually at Mulago Hospital pediatric surgery clinic (956) and the number of elective cases that actually took place (46) in 2020, we estimate that 910 patients did not receive treatment for an elective pediatric surgical condition at Mulago Hospital in 2020.

This paucity of care, however, is likely just a fraction of the unaddressed burden of pediatric surgical disease in Uganda in 2020. These 910 cases do not include patients who remain undiagnosed and therefore have not been referred to pediatric surgery, those seen at the other tertiary pediatric facility in Mbarara, pediatric surgery cases at rural facilities, emergency cases that may have never presented due to the pandemic, or the backlog of cases from previous years that were never addressed.

Further characterizing the effect of the pandemic on the burden of pediatric surgical disease is important as local and international stakeholders aim to understand and advocate for measures to re-establish and expand access to care. In our analysis, quantifying the losses due to missing treatment shows 10,620 DALYs lost just from the 910 patients who missed surgical care in 2020, translating to economic impact between $23 and 122 million USD. These large numbers for a single year of missed elective cases at one facility call for prompt and prudent large-scale measures to address these needs. Clearly the effect of the COVID-19 pandemic is greater than the impact on these Ugandan children and their surgical disease alone. Nevertheless, they are a population that is easily overlooked. Quantifying the impact of the pandemic is one step in bringing to light the significant burden they are bearing.

Our analysis is not without limitations. There are concerns about the accuracy of Disability Weights (DW) in pediatric surgical patients [9]. Even though DWs for pediatric surgical disease are relatively new, it is one of the most useful tools for comparing different diseases and treatments. While not as robustly validated as DW estimates for other populations, DW is nonetheless commonly used to quantify and compare pediatric surgical diseases. Importantly it does seem to vary significantly between HMIC and LMIC contexts [12]. Similarly, DALYs have their limitations. The main disadvantage of DALYs might be that they do not fully capture the burden of disease. DALYs focus solely on health and do not capture the broader societal impact of diseases [25]. Nevertheless, DALYs are one of the few metrics health professionals have to measure the impact of healthcare interventions.

Furthermore, age-specific analysis would be ideal, however, given the limitations of the data (patient age was not recorded in the clinic database), we utilized estimates based on the literature [2]. The cases analyzed in this manuscript are only elective cases seen in clinic, not neonates presenting with emergencies. Since the age of the patients is not noted in the data sources we used, we had to estimate the age of the patients based on the median age of Ugandan children, likely an overestimate of the age of the patients. Overestimating the age of the patients is the most conservative approach, as the subsequent calculations for DALY and economic impact are greater when the patients are younger.

Many strides have been made to address the burden of pediatric surgical disease in Uganda. The College of Surgeons of East, Central, and Southern Africa (COSECSA) created a pediatric surgery fellowship in collaboration with international faculty. KidsOR, an international non-profit that builds pediatric operating rooms and provides support for healthcare training and surgical infrastructure, has built four pediatric operating rooms in Uganda with plans for a fifth theater in Mbarara. The newly built Children's Surgery Hospital in Entebbe had a delayed opening due to the pandemic, but started operating in 2021 and is able to provide elective surgical care for children from many different countries in Sub-Saharan Africa.

Although surgical mission trips have the potential to be impactful, capacity building initiatives, such as COSECSA's pediatric surgery fellowship and KidsOR's longitudinal infrastructure support, have become the focus of much global surgery work for their potential long-term impact. Given the acuity of the current burden of disease, however, additional novel solutions and intervention should be given consideration in order to help address the increased backlog of cases and the acuity of surgical care that COVID-19 has created.

The Pediatric Emergency Surgery Course is a validated pediatric surgery course for rural healthcare providers that has been given four times in Uganda between 2018 and 2022. The course is designed to improve referral patterns for complex cases and improve provider confidence to handle elective cases, such as hernia repair. Surveys from course participants revealed that additional hands-on training was

the highest priority intervention for them to deliver pediatric surgical care. [26]

Targeted, longitudinal surgical camps could be given in conjunction with the Pediatric Emergency Surgery Course. This model would provide both didactics and an opportunity to provide hands-on, mentored practice for anesthesia and surgical providers in these communities. A similar program in India had the added, significant benefit of dramatically improving communication and referrals between district hospital providers and the local pediatric surgeons and anesthesiologists who taught the course [27]. This model addresses elective cases and helps prevent them from becoming emergency cases. It also addresses the urgency of the situation on the ground and provides opportunity for a sustainable impact so that appropriate ongoing incident cases can be safely managed in these locations independent of outside support.

Additional funding and infrastructure for treating pediatric surgical patients is needed in Uganda and other LMICs to address the backlog and ongoing needs. Global interventions for these vulnerable and neglected patients are critical to prevent ongoing suffering and disability, and to prevent their problems from becoming emergencies, with the attendant increase in morbidity and mortality.

Conclusion

COVID-19 damaged the global surgery ecosystem in a profound way. Logbooks in Uganda revealed that COVID-19 made an unmet burden of disease acutely worse. The burden of unmet pediatric surgical need in Uganda is extremely large and growing, affecting children, their families, and the economy. This is an evolving crisis and will result in significant disability and death if it remains unaddressed. Local and international stakeholders must increase their efforts and consider novel approaches to help support surgery during and after the pandemic.

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