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ORIGINAL SCIENTIFIC REPORT

Can Economic Performance Predict Pediatric Surgical Capacity in Sub-Saharan Africa?

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Abstract

Background The relationship between economic status and pediatric surgical capacity in low- and middle-income countries (LMICs) is poorly understood. In sub-Saharan Africa (SSA), Nigeria accounts for 20 % of the population and has the highest Gross Domestic Product (GDP), but whether this economic advantage translates to increased pediatric surgical capacity is unknown. This study compares the pediatric surgical capacity between Nigeria and other countries within the region.

Methods The Pediatric Personnel, Infrastructure, Procedures, Equipment and Supplies (PediPIPES) survey, a recent tool that is useful in assessing and comparing the capacity of health facilities to deliver essential and emergency surgical care (EESC) to children in LMICs, was used for this evaluation.

Results Data from hospitals in Nigeria ($n = 24$) and hospitals in 17 other sub-Saharan African countries ($n = 25$) were compared. The GDP of Nigeria was approximately twenty-five times the average GDP of the 17 other countries represented in our survey. Running water was unavailable in 58 % of the hospitals in Nigeria compared to 20 % of the hospitals in the other countries. Most hospitals in Nigeria and in the other countries did not have a CT scan (67 and 60 %, respectively). Endoscopes were unavailable in 58 % of the hospitals in Nigeria and 44 % of the hospitals in the other countries.

Conclusions Despite better economic indicators in Nigeria, there were no distinct advantages over the other countries in the ability to deliver EESC to children. Our findings highlighted the urgent need for specific allocation of more resources to pediatric surgical capacity building efforts across the entire region.

Introduction

It is imperative that pediatric surgical care be considered an essential part of basic health care for children in every country, including low- and middle-income countries (LMICs) where pediatric surgery is frequently considered to be a costly luxury. More than forty percent of the total population of sub-Saharan Africa (SSA) is less than 15 years [1], and by the time, a child in SSA is 15 years, the approximate cumulative risk of acquiring a surgical condition is 85.4 % [2]. Several recent studies have also documented the huge unmet pediatric surgical needs in the LMICs of SSA [3–8]. Certainly, to improve the well-being

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of children across the region, their surgical needs must be addressed. Unfortunately, pediatric surgery is not a priority for many Sub-Saharan African governments or their partner international organizations [9].

In contrast, high-income countries (HICs) with their more efficient health systems generally have superior health indices compared to LMICs [10]. This is likely due to greater availability of resources, which is related to the underlying better economic performance. Although the level of economic performance of a country may influence the overall progress in most sectors of the country, how it relates to the provision of surgical care to children is generally unknown. This is because until recently, surveys of pediatric surgery capacity have rarely been conducted. The Pediatric Personnel, Infrastructure, Procedures, Equipment and Supplies (PediPIPES) survey is a recent tool that is useful in assessing and comparing the capacity of health facilities to deliver essential and emergency surgical care (EESC) to children in LMICs [11]. Using PediPIPES, data on pediatric surgery capacity in parts of SSA has recently become available for Nigeria and other countries in West Africa [11]. Nigeria accounts for 20 % of the total population of SSA and has the largest economy in Africa—ranking first among African countries in the World Bank Gross Domestic Product report 2013 [12]. This study evaluates whether or not Nigeria's economic advantage correlates to a better pediatric surgical capacity in the country compared to other countries in SSA.

Methods

Data sources

In a survey of health facilities in SSA conducted in 2013, pediatric surgical capacity data were conveniently collected by distribution of the PediPIPES tool to surgeons, interview of practice administrators, and site visits. For this report, the already published data from the West African subregion and the unpublished data from the other subregions of SSA were used. The data were sorted by countries, and the survey findings of the facilities in Nigeria were compared with 17 other SSA countries. All the surveyed facilities were included in the evaluation. The data used in this study for the assessment of the economic performance of countries were taken from World Bank reports [12–15].

Statistical analyses

Descriptive statistics were computed, and Fisher's exact tests were used to test for statistical difference of the proportional availability of each survey item in facilities in Nigeria compared to the other SSA countries. Alpha was as set at 0.05. All analyses were done using Microsoft Excel ver. 14.0 (Microsoft Corp., Redmond, WA, USA) and Stata/SE 12.1 (Stata Corp., College Station, TX, USA). Missing data were <5 % and were excluded from the calculations of proportions.

Results

Twenty-four hospitals in Nigeria and twenty-five hospitals in 17 other sub-Saharan African countries—Burkina Faso (1), Cameroon (2), Ethiopia (3), Ghana (2), Guinea (1), Ivory Coast (2), Kenya (1), Liberia (3), Malawi (2), Niger (1), Rwanda (1), Senegal (1), Sierra Leone (1), Tanzania (1), Togo (1), Uganda (1), and Zimbabwe (1) were surveyed.

Table 1 shows important demographic and economic characteristics of the surveyed countries on the two arms of our evaluation. In 2013, the GDP and GDP per capita of Nigeria compared to the average GDP and average GDP per capita of the 17 other countries represented in our survey were roughly 25 times more and 4 times more, respectively. In 2012, the total health expenditure of Nigeria was 20 times more than the average total health expenditure for the other 17 countries, and the health

Table 1 Relevant demographic and economic characteristics of countries represented

Factor	Nigeria ($n = 24$)	Other ($n = 25$)
Total population in millions (% of population <15 years)	173.6 (44)	406 (44)
GDP (millions of US$)	522,638	20,956*
GDP per capita (US$)	3006	812*
Total health expenditure in millions of US$ (% of GDP)	31,880 (6.1)	1634 (7.8)**
Health expenditure per capita (US$)	94.33	51.01**

Population and GDP data from year 2013 [1, 12, 13]; health expenditure data from year 2012 [14, 15]

* Average sums for the other 17 SSA countries

** Average sums for 16 of the other 17 SSA countries, unavailable data for Zimbabwe

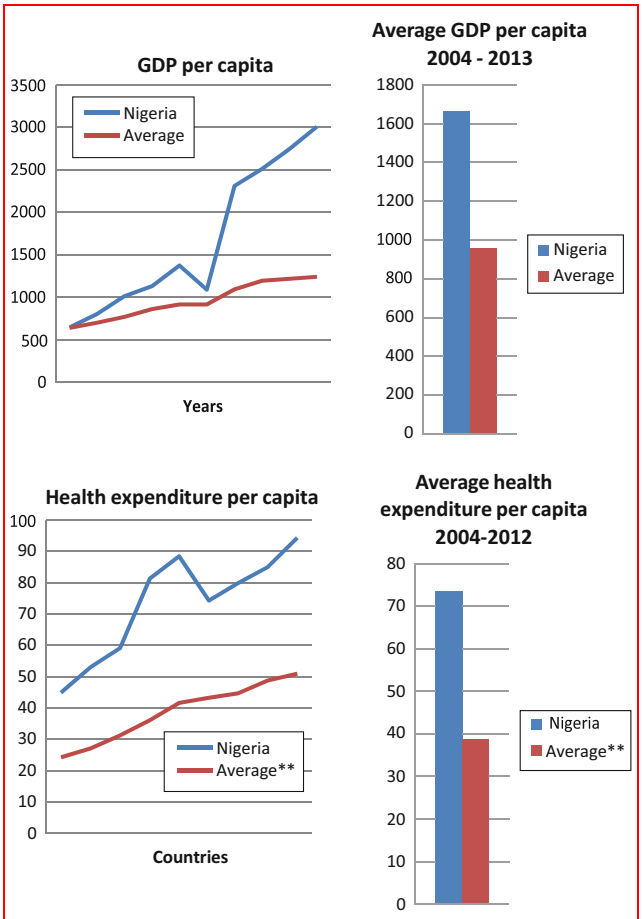

Fig. 1 GDP per capita and Health expenditure per capita of Nigeria vs. Others [13, 15]. *Average sums for the other 17 SSA countries; **Average sums for 16 of the other 17 SSA countries, unavailable data for Zimbabwe

expenditure per capita was approximately twice that of the other countries.

The economic advantage of Nigeria is further demonstrated in Fig. 1 below.

Personnel

In Nigeria, there were 1295 personnel at the 24 hospitals surveyed compared to 1115 personnel at the 25 surveyed hospitals in the other SSA countries. Figure 2 illustrates the cumulative personnel distributions of the facilities surveyed. Notably, all surveyed facilities in Nigeria had at least one pediatric surgeon whereas ten (40 %) hospitals surveyed in the other countries did not have any pediatric surgeons (not shown). However, pediatric surgeons and anesthesiologists were by far the smallest proportions of personnel in every hospital surveyed.

Infrastructure

All surveyed hospitals had at least one functioning operating room and a laboratory for testing blood and urine. Facilities in Nigeria and the other countries surveyed had similar percentages for all the assessed infrastructural items except electricity and running water. These two disparately available items were significantly more in the other SSA hospitals than in the Nigerian hospitals (Table 2).

Procedures

Resuscitation, suturing, and wound debridement were performed in all surveyed facilities. The 46 procedures included in the survey were obtainable in about the same

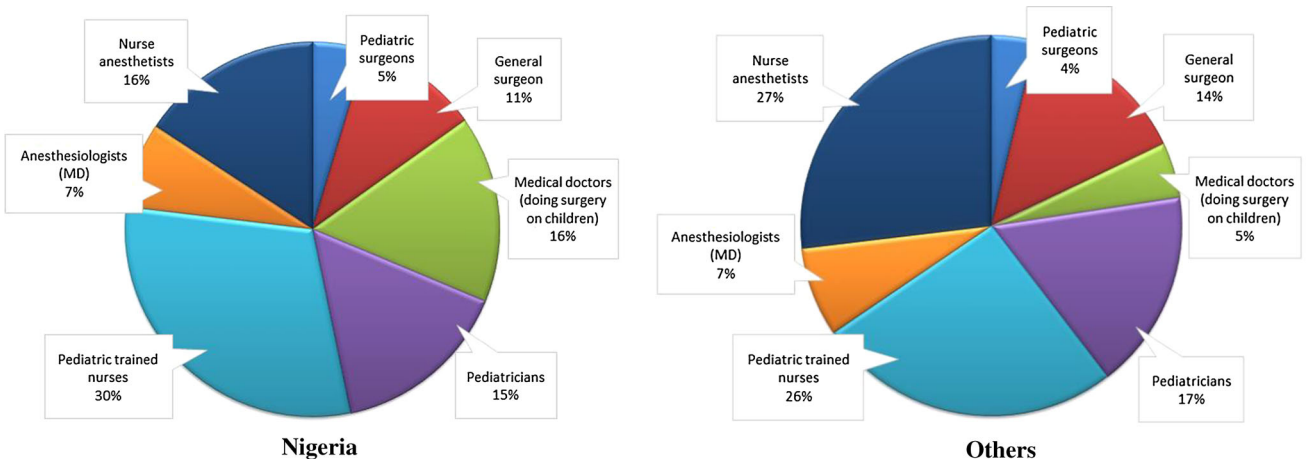

Fig. 2 Personnel distribution of facilities surveyed in Nigeria and Others. *Nigeria* Nigerian hospitals ($n = 24$), *others* other hospitals in 17 SSA countries ($n = 25$)

Table 2 Surveyed hospitals with available infrastructure

Infrastructure	No. (%)	Difference	
	Nigeria	Others	*p* value
Similar			
Operating room	24 (100)	26 (100)	1.00
Laboratory (blood and urine)	24 (100)	26 (100)	1.00
Medical records	22 (92)	24 (96)	0.60
Emergency department	23 (96)	21 (88)	0.61
Newborn incubator	23 (96)	19 (76)	0.10
Postoperative care area	20 (83)	22 (88)	0.70
Special care baby unit (SCBU)	19 (79)	16 (64)	0.35
X-ray	18 (75)	24 (96)	0.05
Blood bank	18 (75)	23 (92)	0.14
Ultrasonography	18 (75)	22 (88)	0.29
Incinerator	15 (63)	16 (67)	1.00
Neonatal intensive care unit (NICU)	11 (46)	15 (60)	0.40
Pediatric ventilator	10 (42)	9 (36)	1.00
Computed tomography	8 (33)	10 (40)	0.77
Different			
Electricity (external source or generator)	15 (67)	*24 (96)*	*0.01*
Running water	10 (42)	*20 (80)*	*0.01*

Italic values are statistically significant

Nigeria Nigerian hospitals ($n = 24$), *others* other hospitals in 18 SSA countries ($n = 25$)

ratio of facilities in Nigeria as facilities in the other surveyed countries (Table 3).

Equipment and supplies

As shown in Tables 4 and 5, all equipment and supply items were similarly available in the Nigerian hospitals as in the other SSA hospitals.

Discussion

The shortcomings of pediatric surgery in SSA have been extensively documented [2–12] but factors that influence the dynamics of pediatric surgical capacity building in the region are yet to be completely understood. One will expect that general proposition that surgical capacity increases with economic development to be true but our study has shown that the personnel, infrastructure, procedures, equipment, and supplies available for provision of EESC to children were similarly deficient in Nigeria as they were in other SSA countries with lower average economic power. This finding challenges the common, even logical, assumption that economic underperformance in the LMICs of SSA correlates with low pediatric surgical capacity in these countries. Nigeria is superior to the other countries in terms of GDP, GDP per capita, total health expenditure, and health expenditure per capita but the point at which health care expenditure translate into increased surgical capacity remains unknown. However, with economic development, middle-income countries like India have built better pediatric surgical capacities [16, 17]. The neglect for inclusion of surgical care among global health priorities is pervasive across all SSA LMICs and may explain why pediatric surgery capacity does not reflect rising economies in the region. Nonetheless, the under-five mortality rate in LMICs in 2012 is more than 13 times the average rate in HICs, and a baby born in 2012 in a HIC can expect to live about 15 to 19 years longer than a baby born in a LMIC in the same year [10]. Therefore, the overall positive effect of economic advancement on the health statistics of a country still remains crucial. Neonates are most affected by these shortages in surgical capacity, with the average mortality of neonatal surgeries in SSA as high as 20–30 % [18].

In resource-poor countries, overall surgical capacity building is deemed too expensive. But then, the estimated cost effectiveness of investing in surgical capacity building is comparable to that of many successful public health strategies [19]. In fact, without prompt investment in surgical capacity building in LMICs, it is projected that the cumulative losses in economic productivity from surgery

Table 3 Surveyed hospitals that had performed procedure at least once

Procedures	No. (%)	Difference	
	Nigeria	Others	*p* value
Similar			
Resuscitation	24 (100)	25 (100)	1.00
Suturing	24 (100)	25 (100)	1.00
Wound debridement	24 (100)	25 (100)	1.00
Incision and drainage of abscess	24 (100)	25 (100)	1.00
Laparotomy	24 (100)	24 (96)	1.00
Appendectomy	24 (100)	24 (96)	1.00
Male circumcision	24 (100)	24 (96)	1.00
Ketamine anesthesia	24 (100)	24 (96)	1.00
Pediatric hernia repair	24 (100)	23 (92)	0.49
Pediatric abdominal wall defects	24 (100)	21 (84)	0.11
Bowel resection and anastomosis	23 (96)	24 (96)	1.00
Repair of testicular torsion	23 (96)	24 (96)	1.00
Closure intestinal stomas	23 (96)	24 (96)	1.00
Pyloromyotomy	23 (96)	24 (96)	1.00
General anesthesia	23 (96)	24 (96)	1.00
Orchiopexy	23 (96)	24 (96)	1.00
Burn management	23 (96)	22 (88)	0.61
Chest tube insertion	23 (96)	21 (88)	0.61
Repair intestinal atresia	23 (96)	21 (84)	0.35
Rectal biopsy	23 (96)	20 (80)	0.19
Ladd procedure	23 (96)	18 (72)	0.05
Creation intestinal stomas	22 (92)	24 (96)	0.61
Resection solid abdominal mass	22 (92)	23 (92)	1.00
Pull-through for Hirschsprung disease	22 (92)	19 (76)	0.25
Repair imperforate anus	22 (92)	17 (68)	0.07
Casting for fracture	21 (88)	25 (100)	0.11
Fracture splinting	21 (88)	25 (100)	0.11
Amputation	20 (83)	25 (100)	0.05
Repair imperforate hymen	20 (83)	24 (96)	0.19
Ovarian cystectomy	20 (83)	24 (96)	0.19
Management of osteomyelitis	20 (83)	24 (96)	0.19
Regional anesthesia blocks	20 (83)	22 (88)	0.70
Skin grafting	20 (83)	22 (88)	0.70
Traction (closed fracture)	20 (83)	22 (88)	0.70
Contracture release	20 (83)	21 (84)	1.00
Spinal anesthesia	20 (83)	21 (84)	1.00
Tracheostomy	20 (83)	18 (72)	0.50
Repair spina bifida	20 (83)	15 (60)	0.11
Insertion G-tube	19 (79)	21 (84)	0.73
Non-operative treatment of clubfoot	18 (75)	24 (96)	0.05
Treatment of open fracture	18 (75)	23 (96)	0.10
Removal of airway and esophageal foreign bodies	16 (67)	17 (68)	1.00
Thoracotomy	16 (67)	16 (67)	1.00
Repair esophageal atresia	16 (67)	13 (52)	0.39
Laparoscopic surgery	11 (46)	9 (36)	0.57
Non-operative reduction of intussusception	10 (42)	10 (42)	1.00

Nigeria Nigerian hospitals ($n = 24$), *others* other hospitals in 17 SSA countries ($n = 25$)

conditions between 2015 and 2030 will be up to $12.3 trillion, as high as a 2 % decrease in the annual GDP growth [20]. Conversely, Meara et al. estimate that it will cost $420 billion to boost up the growth in surgical capacity in 88 LMICs from 2012 to 2030 to the standards of a best-performing LMIC (Mongolia for example), excluding the cost of personnel training [20]. Therefore, since children constitute the major proportion of the SSA LMICs, allotment of adequate funds to pediatric surgical capacity scale-up in these countries as their economies grow is central not only just for building efficient national health systems but also for optimum acceleration in national economic development. National health expenditures are not routinely reported based on clinical services so clear-cut expenses on pediatric surgical services are hard to track. A review of 958 country-generated national health accounts from 1996 to 2010 by the lancet commission on global surgery found that only Georgia and Kyrgyzstan routinely reported expenditures on surgery within their national health accounts [20]. To evaluate and plan properly, it is important to record and track funds invested in pediatric surgery.

Even though the importance of surgery in the public health of developing countries is receiving more attention in recent times, pediatric surgery is yet to be found in the spotlight [7]. The lack of attention to the field may well explain the fewer pediatric surgery training programs and the very low numbers of clinical trainees in SSA that go into the discipline each year [9], hence the shortage of skilled pediatric surgery personnel in the region. Some data from Nigeria in 2011 showed that adult general surgeons were seven times more than pediatric general surgeons (500 general surgeons vs. 72 pediatric surgeons) with a surgeon to total population ratio of 1: 0.3 million people for general surgeons vs. 1: 2.1 million people for pediatric surgeons. There were even higher disparities in personnel trained in pediatric surgical subspecialties, orthopedics, otolaryngology, and neurosurgery for example, relative to their adult counterparts [21]. The lower priority for training personnel in pediatric surgery compared to adult surgery can account for the much lower density of general and subspecialist pediatric surgeons in the country.

Table 4 Surveyed hospitals with equipment always available

Equipment	No. (%)	Difference	
	Nigeria	Others	*p* value
Similar			
Thermometer	24 (100)	24 (96)	1.00
Endotracheal tubes (pediatric)	22 (92)	25 (100)	0.24
Stethoscope	22 (92)	25 (100)	0.24
Oropharyngeal airway (pediatric)	22 (92)	24 (96)	0.61
Anesthesia machine	22 (92)	24 (96)	0.61
Weighing Scale (Infant)	22 (92)	24 (96)	0.61
Sterilizer (autoclave)	22 (92)	24 (96)	0.61
Kidney dish stainless steel	22 (92)	23 (92)	1.00
Suction pump (manual or electric)	21 (88)	24 (96)	0.35
Oxygen: compressed (cylinder)	21 (88)	20 (80)	0.70
Operating room lights	20 (83)	25 (100)	0.05
Oxygen mask & tubing	20 (83)	24 (96)	0.19
Electrocautery machine	20 (83)	24 (96)	0.19
Resuscitator bag valve & mask (pediatric)	20 (83)	22 (92)	0.67
Surgical Instrument sets (abdominal)	20 (83)	22 (88)	0.70
Pulse oximeter	20 (83)	21 (84)	1.00
Blood pressure measuring equipment (Pediatric cuffs)	16 (67)	18 (72)	0.76
Oxygen: concentrator	16 (67)	17 (68)	1.00
Neonatal T-piece (e.g., Jackson Rees)	14 (58)	7 (28)	0.05
Endoscopes (any of esophagoscope/bronchoscope/cystoscope)	10 (42)	14 (56)	0.40
Syringe pumps	9 (38)	13 (52)	0.39
Apneic alarm detector/Apnea monitor	7 (29)	9 (32)	0.76

Nigeria Nigerian hospitals ($n = 24$), *others* other hospitals in 17 SSA countries ($n = 25$)

Our assessment revealed deficiencies in basic infrastructures that must be optimized in order to provide standard surgical care to children. For instance, running water was unavailable in 58 % of the hospitals in Nigeria and in 20 % of the hospitals in the other SSA countries. The surveyed hospitals in the other SSA countries seemed to fare better than the hospitals in Nigeria in terms of infrastructures as they had greater or equal percentages of availability for most of the assessed infrastructural items, but the availabilities were still inadequate.

Safe and efficient surgical care requires optimal staff, stuff, space, and systems, and all these aspects need to be addressed [22, 23]. The amount of surgical procedures successfully carried out in a country as a proportion of the number of surgeries needed is a fair proxy measure of the surgical capacity of the country [24]. It is encouraging that many simple procedures had been performed at least once at majority of the surveyed hospitals in Nigeria and the other SSA countries. However, different from the recent trend of care seen in the developed world, the less invasive surgical procedures including laparoscopic surgeries and non-operative reduction of intussusception were still obtainable at less than half of the hospitals in both Nigeria and the other SSA countries [25]. More so, the success rates of the procedures reported to have been attempted in these facilities cannot be ascertained from our study and they may indeed be considerably low due to limitations in the anesthesia workforce and intensive care support.

Equipment and supply items specific for pediatric patients were in short supply in many assessed hospitals in both Nigeria and other SSA countries. The items lacking included essentials such as pediatric resuscitator bag valves and masks, pediatric cuffs for measuring blood pressure, neonatal T-pieces, nasogastric tubes of size 12F or smaller, urinary catheters including size 6F, and chest tubes of size 12F or smaller.

The aggregate population of the countries represented in our study accounts for about 65 % of the total population of SSA but the small sample sizes of surveyed hospitals in our assessment relative to the total number of hospitals in SSA may very well be a limitation to the generalizability of our study. However, our sample sizes were still robust enough to reveal the deficiencies in the region and for effective comparisons between our two study groups. Yet, there is still a need for more inclusive surveys of facilities

Table 5 Surveyed hospitals with supplies always available

Supplies	No. (%)	Difference	
	Nigeria	Others	*p* value
Similar			
Syringes	24 (100)	25 (100)	1.00
Gloves (sterile)	24 (100)	22 (88)	0.24
Gloves (examination)	24 (100)	22 (88)	0.24
IV cannulas	23 (96)	25 (100)	0.49
Intravenous fluid infusion sets	23 (96)	24 (96)	1.00
Face masks	23 (96)	24 (96)	1.00
Blood transfusion sets	23 (96)	23 (92)	1.00
Sterile gauze	23 (96)	23 (92)	1.00
Scalpel blades	23 (96)	22 (88)	0.61
Disposable needles	22 (92)	24 (100)	0.49
Bandages sterile	22 (92)	22 (92)	1.00
Adhesive tape	21 (88)	24 (96)	0.35
Boots (theater shoes)	21 (88)	23 (92)	0.67
Tourniquet	21 (88)	21 (84)	1.00
Apron	21 (88)	19 (76)	0.46
Gowns (for surgeon/scrub nurse)	20 (83)	23 (92)	0.42
Drapes (for operations)	19 (79)	23 (92)	0.25
Suture (absorbable)	19 (79)	21 (84)	0.73
Sharps disposal container	18 (75)	22 (88)	0.29
Suture (non-absorbable)	18 (75)	21 (84)	0.50
Nasogastric tubes 12F or smaller	18 (75)	19 (76)	1.00
Urinary catheters (must include 6F)	16 (67)	16 (64)	1.00
Tracheostomy tubes	15 (63)	19 (76)	0.36
Eye protection (goggles, safety glasses)	10 (42)	16 (64)	0.16
Chest tubes 12F or smaller	10 (42)	15 (60)	0.26
Laparoscopic supplies	3 (13)	6 (24)	0.29

Nigeria Nigerian Hospitals ($n = 24$), *others* other hospitals in 17 SSA countries ($n = 25$)

in the region. Another drawback of this article is that, as is the case for every survey that includes self-reported data, the validity of our assessment depends on the accuracy of the reported data.

Although experience and practice suggests that surgical care for children is more neglected than the rest of surgical care in the SSA region, we could not find published studies directly comparing efforts in addressing the deficiencies in the rest of surgical care to that of surgical care for children. Better health information systems will lead to more robust data collection and better evidence. Future studies that advocate for the optimization of surgical care for children in the region can further explore the seemingly disparately lower efforts channeled toward pediatric surgery.

Conclusions

Economic performance is not a reliable predictor of pediatric surgical capacity in SSA. This is demonstrated by our findings that despite better economic indicators in Nigeria, there were no distinct advantages over the other countries in the ability to deliver EESC to children. Attention to developing pediatric surgical capacity in SSA remains poor, highlighting the urgent need for specific allocation of more resources to pediatric surgical capacity building efforts across the entire region.

Compliance with ethical standards

Conflict of interest None.

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