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A Pilot Survey of Pediatric Surgical Capacity in West Africa

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Abstract

Background While some data exist for the burden of pediatric surgical disease in low- and middle-income countries (LMICs), little is known about pediatric surgical capacity. In an effort to better plan and allocate resources for pediatric surgical care in LMICs, a survey of pediatric surgical capacity using specific tool was needed.
Methods Based on the previously published Surgeons OverSeas Personnel, Infrastructure, Procedure, Equipment, and Supplies (PIPES) survey, a pediatric PIPES (PediPIPES) survey was created. To ensure relevance to local needs and inclusion of only essential items, a draft PediPIPES survey was reviewed by nine pediatric surgeons and modifications were incorporated into a final tool. The survey was then distributed to surgeons throughout sub-Saharan Africa. Data from West Africa (37 hospitals in 10 of the 16 countries in the subregion) were analyzed.
Results Fewer than 50 % (18/37) of the hospitals had more than two pediatric surgeons. Neonatal or general intensive care units were not available in 51.4 % (19/37) of hospitals. Open procedures such as appendectomy were performed in all the hospitals whereas less-invasive interventions such as non-operative intussusception reduction were done in only 41 % (15/37). Life-saving pediatric equipment such as apnea monitors were not available in 65 % (24/37) of the hospitals.
Conclusions The PediPIPES survey was useful in documenting the pediatric surgical capacity in West Africa. Many hospitals in West Africa are not optimally prepared to undertake pediatric surgery. Our study showed shortages in personnel, infrastructure, procedures, equipment, and supplies necessary to adequately and appropriately provide surgical care for pediatric patients.

Introduction

The focus of pediatric health care services in low- and middle-income countries (LMICs) has conventionally been on prevention and treatment of communicable diseases, and malnutrition, but recent studies have documented the burden of pediatric surgical disease in these countries [1–4]. To reduce the high rates of childhood morbidity and

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mortality in LMICs [5], several authors have noted the importance of providing optimal access to pediatric surgical care [6–8]. Yet, little is known about the pediatric surgical capacity in the LMICs, where surveys of surgical capacity tend to be heavily weighed on adults [9–20]. Also, the relatively few published reports on pediatric surgical capacity have been based on tools designed for adults [21, 22].

Available tools to assess capacity to provide essential surgical care include the WHO Tool for Situational Analysis [23] and the Surgeons Overseas (SOS) Personnel, Infrastructure, Procedure, Equipment, and Supplies (PIPES) tool [24]. Although surveys using these tools have included aspects of pediatric surgical care, the tools were designed for a general assessment of overall surgical capacity, with limited relevance to children. We set out to use a novel, specific tool to assess capacity to provide essential and emergency surgical care (EESC) to children in LMICs. The new tool, the Pediatric Personnel, Infrastructure, Procedure, Equipment, and Supplies (PediPIPES) tool, was based on PIPES, and also allows for the calculation of a PediPIPES index.

In this study, we reported the findings of a pilot survey, conducted using the PediPIPES tool, of pediatric surgical capacity in West Africa.

Materials and methods

Survey tool

From the SOS PIPES survey, we developed the pediatric PIPES (PediPIPES) survey tool to specifically assess pediatric surgical capacity. A description of the original PIPES tool was published in 2012 [24]. PediPIPES differs from PIPES in that the personnel, infrastructure, procedure, equipment, and supplies sections were modified, where appropriate, to be relevant to pediatric surgical care. To ensure relevance to local needs and inclusion of only essential items, a draft PediPIPES survey was reviewed by four United States and five African pediatric surgeons and modifications were incorporated into a final tool. The final PediPIPES tool has 118 items compared to the PIPES tool with 105 items.

A PediPIPES index was derived in the same manner as the original PIPES index [24], but the weighting of component items were slightly different as explained below. A personnel score (P-score) was calculated by adding all the number of personnel; an infrastructure score (I-score) was calculated by adding the number of incubators, pediatric ventilators, and operating rooms, and one point for each of the 14 infrastructural items that was always available at the facility; a procedure score (Pr-score) was calculated by adding one point for each of the 46 data item procedures performed at the facility; an equipment score (E-score) was calculated by adding one point for each of the 22 equipment items; and supply score (S-score) was calculated by adding one point for each of the 26 supply items. There is no maximum P-score and I-score, whereas the maximum Pr-score, E-score, and S-score are 46, 22, and 26, respectively. The total PediPIPES score for each facility was calculated by summing the P-score, I-score, Pr-score, E-score, and S-score. This number was then divided by the total number of data items (118) and multiplied by ten to create the PediPIPES index. There is no maximum value for the PediPIPES index.

The PediPIPES tool is available as an open source document on the SOS website www.surgeonsoverseas.org.

Data collection and analysis

The PediPIPES survey was conveniently distributed to surgeons throughout sub-Saharan Africa using an email list of pediatric surgeons and general surgeons who also performed pediatric surgical procedures. The email list was compiled by one of the authors (EAA), who is a pediatric surgeon practicing in West Africa. Data collection was from March 2013 to July 2013. Data were aggregated by subregions, and descriptive statistical analyses were computed. Missing data were excluded from calculations of proportions; and these were <5 % for all variables, so no survey item was dropped on the basis of missing data. Using the surveyed facility with the highest PediPIPES index for each country, we compared the pediatric surgical capacity by country. In countries with one surveyed facility, the sole facility was used for the comparison. 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).

Although we distributed surveys to surgeons across sub-Saharan Africa, our sampling method was not systematic, and our email list included very few surgeons from the other subregions outside West Africa; therefore, data from those subregions were rather sparse and the overall response rate of the survey cannot be determined with certainty. For this study, therefore, only the data for health facilities in the West African region were analyzed. All the West African hospitals with at least one completed survey were included in the analysis, and for hospitals with more than one completed survey, the first completed survey was used for the analysis. Data were available from hospitals in ten of the 16 West African countries (Fig. 1).

Results

The thirty-seven healthcare facilities assessed included: 24 in Nigeria; three in Liberia; two in Ghana and Ivory Coast

Fig. 1 Map of West Africa (evaluated countries in *red*)

each; and one in Burkina Faso, Guinea, Niger, Senegal, Sierra Leone, and Togo each. Thirty-two of the thirty-seven (86.5 %) facilities were tertiary; two (5.4 %) were secondary; and district, private, and mission facilities were one each (8.1 %). Three facilities (8.1 %) were exclusively for children.

Personnel

Fewer than half (18/37) of the facilities had more than two pediatric surgeons. Five facilities (13.5 %) had no pediatric surgeon, and other medical doctors operated on children in these facilities. Seven (18.9 %) facilities had no anesthesiologist, and four (10.8 %) facilities had just one anesthesiologist, but all the facilities had at least one nurse anesthetist.

Infrastructure

The number of hospital beds in the facilities ranged from 20 to 2,000 (median = 350), and pediatric hospital beds ranged from 6 to 210 (median = 60). All the facilities had at least one operating room and a laboratory to test blood and urine. Medical records, emergency department, postoperative care area, and blood bank were available in majority of the facilities. While at least one functioning newborn incubator and a Special Care Baby Unit were available in most facilities, Neonatal Intensive Care Unit (NICU) or General Intensive Care Unit was available in less than half (48.6 %) of the facilities: 16 (43.2 %) facilities had at least one functioning pediatric ventilator in their NICU or General ICU. Although less expensive diagnostic imaging like plain radiography and ultrasonography were available in more than three-quarters of evaluated facilities, more sophisticated, but essential, computed tomography imaging was available in just 13 facilities (35.1 %) (Table 1).

Table 1 Available infrastructure in evaluated health facilities ($n = 37$)

Infrastructure items	No. (%)*
Operating room	37 (100)
Laboratory (blood and urine)	37 (100)
Medical records	34 (91.9)
Emergency department	34 (94.4)
Newborn incubator	33 (89.2)
Postoperative care area	33 (89.2)
Blood bank	30 (81.1)
Plain radiography	30 (81.1)
Ultrasonography	29 (78.4)
Special Care Baby Unit	27 (73)
Electricity (external source or generator)	27 (73)
Incinerator	21 (56.8)
Running water	19 (51.4)
NICU or General ICU	18 (48.6)
Pediatric ventilator	16 (43.2)
Computed tomography	13 (35.1)

* Missing data excluded from the percent shown when applicable

Procedures

In general, more basic and less intricate procedures were performed more than the sophisticated and complex procedures. Resuscitation, suturing, wound debridement, incision and drainage of abscess, laparotomy, appendectomy, male circumcision, and pediatric hernia repair were performed commonly, but procedures like spinal bifida repair and repair of esophageal atresia were not as common. Non-operative reduction of intussusception and laparoscopic surgery were done in just 15 facilities (40.5 %). Table 2 displays the number and proportions of facilities that had performed the assessed procedures at least once.

Equipment and supplies

Most surveyed hospitals had decent availability of many equipment (thermometer, stethoscope, compressed oxygen, oxygen masks, and tubing, suction, pediatric endotracheal tube, pediatric oropharyngeal airway, and pediatric bag-valve mask), but some life-saving equipment, for example, apnea monitor was unavailable in majority of the hospitals. Most supplies, including examination gloves, sterile gloves, scalpel blades, disposable syringes, disposable needles, intravenous cannulas, and intravenous infusion sets were sufficient. The availability of eye protection was notably low and laparoscopic surgery supplies were not

Table 2 Facilities that had performed procedures at least once ($n = 37$)

Anesthesia No. (%)	Respiratory No. (%)	Gastrointestinal No. (%)	Urogenital No. (%)	Orthopedic No. (%)	Unclassified No. (%)
Ketamine 36 (97.3)	Chest tube insertion 34 (91.9)	Appendectomy 37 (100)	Male circumcision 37 (100)	Fracture splinting 34 (91.9)	Resuscitation 37 (100)
General 35 (94.6)	Tracheostomy 29 (78.4)	Bowel resection and anastomosis 36 (97.3)	Pediatric hernia repair 37 (100)	Casting of fracture 34 (91.9)	Suturing 37 (100)
Regional 31 (83.8)	Thoracotomy 24 (64.9)	Closure of intestinal stomas 36 (97.3)	Orchidopexy 36 (97.3)	Amputation 33 (89.2)	Wound debridement 37 (100)
Spinal 29 (78.4)	Repair of esophageal atresia 24 (64.9)	Pylorotomy 36 (97.3)	Repair of testicular torsion 36 (97.3)	Osteomyelitis management 32 (86.5)	Incision and drainage of abscess 37 (100)
	Removed airway and esophageal foreign bodies 23 (62.2)	Closure of intestinal stomas 35 (94.6)	Repair of imperforate hymen 33 (89.2)	Traction of closed fracture 31 (83.8)	Laparotomy 37 (100)
		Rectal biopsy 34 (91.9)	Ovarian cystectomy 33 (89.2)	Treatment of open fracture 30(81.1)	Pediatric abdominal wall defect repair 35 (94.6)
		Intestinal atresia repair 34 (91.9)		Non-operative treatment of clubfoot 30 (81.1)	Burn management 34 (91.9)
		Ladd procedure 33 (89.2)			Resection of solid abdominal mass 34 (91.9)
		Pull-through procedure for Hirschsprung disease 32 (86.5)			Skin grafting 31 (83.8)
		Repair of imperforate anus 31 (83.8)			Contracture release 30 (81.1)
		Insertion of G-tube 29 (78.4)			Spinal Bifida 28 (75.7)
		Non-operative reduction of intussusception 15 (40.5)			Laparoscopic surgeries 15 (40.5)

Missing data excluded from the percent shown when applicable

Table 3 Equipment and supplies availability in surveyed facilities ($n = 37$)

Equipment and supplies	No. (%)
Thermometer	37 (100)
Gloves (examination)	35 (100)
Stethoscope	35 (97.2)
Endotracheal tube (pediatric)	35 (94.6)
Weighing scale (infant)	35 (94.6)
Gloves (sterile)	33 (94.3)
Syringes	33 (94.3)
Oropharyngeal airway (pediatric)	34 (91.9)
Anesthesia machine	34 (91.9)
Kidney dish	34 (91.9)
Sterilizer (autoclave)	34 (91.9)
Intravenous fluid infusion set	34 (91.9)
Intravenous cannulas	34 (91.9)
Oxygen mask and tubing	33 (89.2)
Suction pump (manual or electric)	33 (89.2)
Operating room light	33 (89.2)
Blood transfusion set	33 (89.2)
Gauze (sterile)	33 (89.2)
Face masks	33 (89.2)
Surgical instrument set (abdominal)	32 (86.5)
Electrocautery machine	32 (86.5)
Disposable needles	32 (86.5)
Scalpel blades	32 (86.5)
Compressed oxygen in cylinder	31 (83.8)
Bandages (sterile)	31 (83.8)
Adhesive tape	31 (83.8)
Bag-valve mask (pediatric)	30 (83.3)
Pulse oximeter	30 (81.1)
Boots (theater shoes)	30 (81.1)
Gowns (for surgeon/scrub nurse)	30 (81.1)
Tourniquet	29 (78.4)
Drapes (for operations)	29 (78.4)
Suture (absorbable)	28 (75.7)
Suture (non-absorbable)	28 (75.7)
Sharps disposal container	28 (75.7)
Apron	28 (75.7)
Nasogastric tube (12F or smaller)	27 (77.1)
Oxygen concentrator	26 (70.3)
Blood pressure measuring equipment (pediatric cuff)	26 (70.3)
Tracheal tubes	25 (67.6)
Urinary catheters	24 (64.9)
Chest tubes (12F or smaller)	18 (48.6)
Neonatal T-piece	17 (45.9)
Endoscope (any of esophagoscope/ bronchoscope/cystoscope)	17 (45.9)
Syringe pumps	16 (43.2)
Eye protection (goggle, safety glasses)	16 (43.2)
Apnea alarm detector/apnea monitor	13 (35.1)
Laparoscopic supplies	5 (13.5)

Missing data excluded from the percent shown when applicable

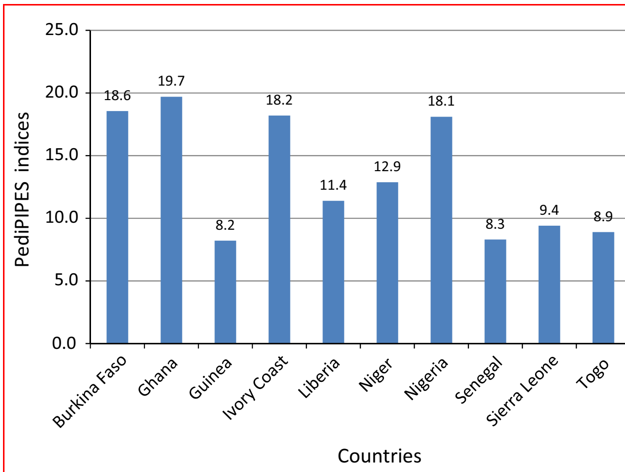

Fig. 2 Hospitals with highest PediPIPES indices by country

surprisingly scarce. Table 3 shows the availability of all the assessed equipment and supplies.

PediPIPES scores and indices

The discrete PediPIPES scores of facilities with the highest PediPIPES indices by country are shown in Table 4, and Fig. 2 shows the aggregate PediPIPES indices of these facilities.

Discussion

This cross-sectional survey of 37 health facilities in West Africa, using the novel PediPIPES tool, highlights the deficiencies in the pediatric surgical capacity of the region. The study revealed substantial shortages in personnel, infrastructure, procedures, equipment, and supplies. The PediPIPES tool, developed specifically to assess capacity to provide EESC to children in LMICs, was designed to be easy to administer, allow simple data analysis, permit comparison between facilities, and document changes in the pediatric surgical capacity of facilities over time. The ease of administration of PediPIPES tool further confirms the efficacy and simplicity of the original PIPES tool. These surgical

Table 4 PediPIPES scores of hospitals with highest PediPIPES indices by country

	Burkina Faso	Ghana	Guinea	Ivory Coast	Liberia
Total population in millions (% of population <15 years)	18.0 (46)	26.1 (39)	11.8 (43)	21.1 (42)	4.4 (43)
Number of beds (pediatric)	125 (125)	2,000 (135)	80 (24)	817 (80)	250 (60)
PediPIPES personnel score	135	99	37	118	21
PediPIPES infrastructure score	10	44	9	15	24
PediPIPES procedures score	37	46	37	38	43
PediPIPES equipment score	16	21	7	20	21
PediPIPES supplies score	21	22	7	24	25
	Niger	Nigeria	Senegal	Sierra Leone	Togo
Total population in millions (% of population <15 years)	16.9 (50)	173.6 (44)	13.5 (44)	6.2 (42)	6.2 (42)
Number of beds (pediatric)	900 (145)	738 (136)	180 (180)	300 (20)	50 (15)
PediPIPES personnel score	40	98	23	21	5
PediPIPES infrastructure score	25	24	14	15	17
PediPIPES procedures score	45	45	42	39	39
PediPIPES equipment score	19	21	19	18	19
PediPIPES supplies score	23	26	18	18	25

Population data from 2013 World Population Data Sheet [25]

capacity surveys are designed primarily for LMICs, and the threshold levels of resources defined in these surveys are likely too basic for most high-income countries.

According to the World Health Organization 2012 report on the levels and trends of child mortality, "the highest rates of child mortality are still in Sub-Saharan Africa—where one in nine children dies before age five, more than 16 times the average for developed regions (1 in 152)—and Southern Asia (1 in 16). As under-five mortality rates have fallen more sharply elsewhere, the disparity between these two regions and the rest of the world has grown [5]". Nigeria alone accounts for 11 % of the world's under-five deaths [5]. Children constitute a significant proportion (>40 %) of the total West African population [25], and as such, to reduce the overall burden of childhood disease, their surgical needs cannot be overlooked. A survey of district hospitals in Rwanda by Notrica et al. reported that pediatric surgical cases constitute only 1 % of their total number of surgical procedures performed each year [20]. A countrywide survey of surgical need in Sierra Leone showed that 17.6 % of children assessed had a potentially treatable surgical condition; however, there was no registered pediatric surgeon in the whole country [1].

This study further demonstrates the severe deficiency of pediatric specialist physicians (pediatric surgeons and anesthesiologists) although there were a modest number of ancillary personnel, including pediatric nurses and nurse anesthetists. Other studies have also documented disproportionately higher numbers of low- and intermediate-skilled personnel in health facilities in other LMICs [15–17].

The shortage of anesthesiologists in the region cannot be overlooked. In West Africa, trained anesthesiologists are generally few and pediatric anesthesiologists are even fewer, anesthesia for pediatric surgery is often provided by nonphysicians [26–28]. Lack of pediatric anesthesia expertise likely affects the outcome of surgical procedures and could limit the complexity of procedures that can be performed. The impact may be even more critical in neonates and infants. The PediPIPES tool did not include information on perioperative mortality rates, and this cannot be ascertained from this survey, but available literature from the region suggests that the mortality rates, particularly for neonatal surgery and emergency pediatric surgery are high [26–30].

Infrastructural facilities in most of the 37 hospitals assessed could be regarded as substandard in several aspects of pediatric surgical care. Contrary to health facilities in most developed countries where the supply of electrical power and water is universal, our assessment and several published studies have steadily shown lack in constant supply of running water and electricity in health facilities in LMICs [9, 16–18, 31]. Since water and electricity are indispensable needs, if appropriate funds are channeled to upgrading the electrical power and water supply infrastructures in the region, this area could be an opportunity for massive improvement in the quest to make the standards of facilities in the region more comparable with the much higher standards of high-income countries.

Although our study showed that many equipment and supplies tended to be available it still highlighted significant deficiencies in some items, such as apnea monitors, crucial for optimal care of children. The shortages in personnel, infrastructure, equipment, and supplies could somewhat account for the insufficient amounts of procedures performed, with minimally invasive, sophisticated procedures more than the basic procedures. Even in facilities that performed simple procedures frequently, the standard of surgical care raises concern, considering the significant lack of essentials like oxygen, constant electricity, and running water in these facilities.

Analogous to PIPES, the PediPIPES score and index can be used as a compound measure for assessment and comparison of pediatric surgical capacity across health facilities. Our findings are consistent with the deficiencies in overall surgical capacity documented in previous studies [10–13]. Furthermore, the impact of the generally low pediatric surgical capacity in West Africa on the quality of pediatric surgical training in the region is worrisome. Even with the increasing numbers of qualified pediatric surgeons who could serve as faculty, most training programs are limited by the poor state of infrastructure and equipment. In a survey of pediatric surgeons trained in West Africa, conducted in 2009, 38 % of respondents reported that these deficiencies negatively affected the quality of local training programs, and recommended that residents undergo additional training in centers in Europe and North America [32].

Limitations

One limitation of this pilot study is the small sample size of hospitals surveyed as compared to the total number of hospitals in the region. As a result, hospitals with the best PediPIPES indices were used to compare the pediatric surgical capacity of the different countries, and this may mask the actual hierarchy of the performance of the individual countries. Future surveys should include a more comprehensive assessment of facilities in the region. More so, the facilities surveyed here were mostly tertiary or referral hospitals. Our sample size was not sufficiently robust for the evaluation of the capacity across hospitals of different sizes and complexities (i.e., secondary versus tertiary level hospitals, or general versus pediatric specialist hospitals). In addition, this survey may have oversampled Nigerian hospitals compared to its West African neighbors. While Nigeria has the largest economy in West Africa [33], and vastly more teaching hospitals and pediatric training programs than all the other West African countries combined, further detailed studies to compare the isolated pediatric surgical capacity of Nigeria and the rest of West Africa are recommended.

Another limitation, similar to most published capacity surveys, is that data reported here depends on the validity of the answers of the survey respondents. Ideally, the most knowledgeable person about a health facility should complete these capacity surveys, but in most cases, the most appropriate respondent cannot be determined with absolute certainty. In fact, in some cases, the surgeons may not be as knowledgeable about the availability of certain infrastructure, equipment, and supplies, as hospital administrators or nursing personnel. Lastly, the study was a snapshot of hospitals, different supplies might be available at different times, and infrastructures might improve or depreciate over time. To document trends, similar assessments should be repeated over time.

Conclusion

The novel PediPIPES tool has identified shortages and inadequacies in personnel, infrastructure, procedures, equipment, and supplies, necessary for optimal surgical care of children in West Africa. Personnel shortages should be addressed by fast tracking the training of pediatric surgeons and support personnel through dedicated mentoring to increase enrollment into the specialty. Collaboration between international pediatric surgical groups and West African pediatric surgeons and training colleges should be intensified to strengthen the quality of available training programs and support local trainers. Advocacy should be intensified to convince and encourage policy makers and funding agencies to upgrade and strengthen the infrastructure, and invest in provision of appropriate equipment. Reliable supply mechanisms need to be established to ensure continuous and sustainable availability of relevant and appropriate supplies. Once problems with personnel, infrastructure, equipment, and supplies are addressed, it should become possible to perform relevant procedures that would ensure optimal surgical care for children in the setting. The PediPIPES tool is useful and is recommended for use in assessing pediatric surgical capacity in LMICs.

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