Title : "PEDIATRIC SURGERY AND ANESTHESIA CAPACITY IN RWANDA : A SURVEY OF DISTRICT AND REFERRAL HOSPITALS"

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Dissertation submitted in fulfillment of the requirements of the degree of **Master of Anesthesiology**, School of Medicine, College of Medicine and Health Sciences, University of Rwanda.

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December 20, 2021

DECLARATION

I declare that this Dissertation contains my own work except where specifically acknowledged, and it has been passed through the anti-plagiarism system and found to be compliant and this is the approved final version of the Dissertation:

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ABSTRACT

Background: The Lancet Commission on Global Surgery (LCoGS) released a report in 2015 that highlighted significant inequalities in the availability of safe surgery and anesthetic care around the world. Rwanda could serve as a model for other countries that are developing their own national surgical strategic plans but like much of Africa, the country has a severe shortage of surgical and anesthetic capacity, with numbers more than ten-fold lower than in the United States and Europe.

Aim: The aim of the study was to access pediatric surgical and anesthesia capacity in district and tertiary hospitals in Rwanda.

Methodology: Descriptive, cross-sectional survey was distributed to all district and tertiary hospitals in Rwanda to assess pediatric surgical and anesthesia capacity. The assessment focused on workforce, infrastructure, procedures, Equipment and supplies, Service delivery, Information management, blood product and international cooperation. The WFSA AFAT and PediPIPES tools were used for data collection.

Results: Results show scarcity in pediatric surgical and anesthesia workforce. No pediatric surgeon or anesthesiologist was available at the level of district hospitals. Surgeries on children were done by medical doctors and anesthesia conducted by non-physician anesthetists at the majority of surveyed district hospitals. The majority of hospitals lacked post-operative ICU/NICU services. Bellwether procedures were done at most hospitals with more complex and specialized procedures done at tertiary level of care. Oxygen, water, electricity and blood products were almost available in all surveyed hospitals. Scarcity of specific pediatric size equipment was noted. Tracking of perioperative complications was poor in most cases. Most hospitals reported receiving supply donations from international partners.

Conclusion: Several gaps were noted in each of the domain of focus. The results from this study could serve as a baseline to improve perioperative care of children in Rwanda as well as a guide to advocate for more resource and interventions aimed at strengthening pediatric perioperative care.

LIST OF KEY WORDS

Pediatric surgery

Pediatric anesthesia

Surgical capacity

Anesthesia capacity

District hospital

Provincial hospital

Tertiary hospital

Rwanda

LIST OF SYMBOLS AND ACRONYMS

AFAT: Anesthesia Facility Assessment Tool

ASA: American Society of Anesthesiology

CNTS: National Centre for Blood Transfusion

COVID-19: Coronavirus Disease 2019

CPD: Continuing Professional Development

CT scan: Computerized tomography scan

Dr.: Doctor

DRC: Democratic Republic of Congo

DVT: Deep Vein Thrombosis

HIV: Human Immunodeficiency Virus

HRH: Human Resources for Health

IBM: International Business Machines Corporation

ICU: Intensive Care Unit

IQR: Interquartile Range

IV: Intravenous

KATH: Komfo Anokye Teaching Hospital

LCoGS: Lancet Commission on Global Surgery

LMICs: Low- and Middle-Income Countries

MoH: Ministry of Health

NGT: Nasogastric Tube

NIBP: Non-invasive Blood Pressure

NICU: Neonatal Intensive Care Unit

NY: New York City

OR: Operating Room

PACU: Post-anesthesia Care Unit

PediPIPES: Pediatric PIPES

PGSSC: Program in Global Surgery and Social Change

PIPES: Personnel, Infrastructure, Procedure, Equipment and Supplies

SAT: Surgical Assessment Tool

SOS: Surgeons OverSeas

SPSS: Statistical Package for the Social Sciences

U/S: Ultrasound machine

US: United States

USA: United States of America

WFSA: World Federation of Societies of Anesthesiologists

WHO: World Health Organization

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CHAPTER 1: GENERAL CONSIDERATIONS

1.1 Background

The Lancet Commission on Global Surgery (LCoGS) released a report in 2015 that highlighted significant inequalities in the availability of safe surgery and anesthetic care around the world(1). Some of LCoGS guidelines for countries by 2030 include having a surgeon, anesthesiologist, and obstetrician density of 20 per 100 000 people, a minimum of 5 000 surgical procedures per 100 000 population, and recording 100 percent of perioperative death rates(1,2). In low middle-income countries (LMICs), shortages in the manpower, infrastructure, and drugs for safe anesthesia and surgery continue to be a major impediment to reaching these goals and improving outcomes(3,4).

Rwanda is a landlocked, densely populated country in East Africa with a population of over 67 percent under the age of 20(5,6). Rwanda's infrastructure, health care system and medical education were destroyed during the Tutsi Genocide in 1994, but the country's fate has been changed by the incumbent Government's vision 2020 Initiative.

Rwanda could serve as a model for other countries that are developing their national strategic plans. Increased physician monitoring, education, and strategic provider placement are all part of the approach(7). However, like much of Africa, Rwanda has a severe shortage of surgical and anesthetic personnel, with numbers more than tenfold lower than in the United States and Europe(8).

A study describing the pattern of pediatric surgeries at 2 teaching universities in Rwanda reported that a total of 1274 children operated between 2013 and 2014, with the proportion of under 5 years old being 45.1%. Trauma and burns (36%), congenital malformations (23%) and surgical infections (15%) were the most common diagnosis(9).

The findings of Rwanda's first prospective pediatric anesthesia database from three tertiary public hospitals revealed that 7 deaths and 5 cardiac arrests occurred most frequently in children with ASA 3 and ASA 4 who were less than 1 week old, had emergency surgery, or had a concurrent respiratory infection(10). Several writers have stressed the necessity of providing

appropriate access to pediatric surgical treatment in LMICs to minimize the high rates of childhood morbidity and mortality(11).

Previous surveys show that, in order to improve care and comply with the WHO recommendations, district hospitals in Rwanda must continue to develop emergency and essential surgical services(12). They have found major flaws in both financial and human resources. Unfortunately, these studies were conducted over a decade ago, are out-of-date in terms of Rwanda Demographic Health Survey results, and are mostly focused on adults(8).

In Rwanda, nothing is known regarding the capacity for pediatric surgery and anesthesia.

The purpose of this study was to address the gap.

1.2. Aim and objectives

1.2.1 Aim

The aim of the study is to assess pediatric surgical and anesthesia capacity in Rwanda

1.2.2 Objectives

- To report findings about pediatric surgical and anesthesia personnel, infrastructure, procedure, equipment and supply capacity of district and referral hospitals in Rwanda
- To highlight deficiencies in the pediatric surgical and anesthesia capacity of district and referral hospitals in Rwanda
- To calculate the PediPIPES indices for district and referral hospitals in Rwanda
- To calculate the mean PediPIPES index for Rwanda in comparison with available indices in Africa

1.3: Review of literature

Access to emergency and critical anesthetic and surgical care is recognized as a vital aspect of universal health coverage by the World Health Assembly resolution 68.15. There is also growing acknowledgement that up to one-third of the world's illness burden is surgically correctable, which is more than the combined burden of tuberculosis, HIV and malaria(13,14).

Approximately 1.7 billion children around the world do not have access to safe, cheap, and timely surgical and anesthetic care. Children under the age of 15 make up about half of the population in LMICs, but these nations have manpower shortages, a lack of strong medical schools and children training programs, and inadequate research capacity and money dedicated to children's surgery(15).

According to a study of pediatric surgical capacity in Africa, there are 1.1 hospitals (0.03 dedicated pediatric and 1.1 general), 0.3 intensive care units (0.06 pediatric, 0.2 combined and 0.06 neonatal), 0.17 pediatric surgical wards, and 0.06 burn units per million people. The median pediatric surgical hospital beds per millions of population was 5 (divided between 4 in public institutions and 1 in private) and non-surgical pediatric beds was 26 (20 in public and 6 in private facilities). According to the same study, median pediatric surgical in-patients and outpatients per institution each year were 840 (16 percent neonates, 30 percent infants, 50 percent older children) and 1960 (14 percent neonates, 30 percent infants, 54 percent older children) respectively. The average workload per institution was 852 surgical interventions per year (72 percent major, 61 percent elective, 35 percent emergency, and 37 percent on children below 1 year)(16).

According to a survey conducted in Rwanda in 2011, the average total number of physicians at a district hospital is 11. There were almost no surgeons or anesthesiologists available, thus almost everyone was a general practitioner. Obstetricians and gynecologists were the only surgical experts available, and there were a few of them. An average of three anesthesia technicians is present in every hospital, with one uncertified nurse aiding in anesthesia on occasion(12).

Abdominal wall hernias, bowel obstruction, acute abdomen, appendicitis, orthopedic conditions, and anorectal anomalies were the most common diseases treated in the participating hospitals, according to a study of African pediatric surgeons. For most index surgical diseases, the weighted average percent fatality ranged from 1% in Sierra Leone to 54% in Burkina Faso(16).

Another study in Mongolia found that all hospitals perform basic procedures. Laparotomy, intestinal resection, appendectomy, hernia repair, and circumcision are all procedures performed in all hospitals. Most (71%) do thoracotomy and treat testicular torsion. About a half (57%) do laparoscopy, airway and esophageal foreign bodies removal. Other reported procedures were skin grafting (38%), pyloromyotomy (33%), repair of intestinal (24%) and esophageal atresia (0.5%)(17).

A pilot survey of pediatric capacity in West African hospitals found that many items (thermometer, stethoscope, compressed oxygen, oxygen masks and tubing, suction, endotracheal tubes, oral airways and bag valve mask) are readily available, but some life-saving equipment, such as apnea monitor, is not. The majority of supplies were sufficient, including examination gloves, sterile gloves, scalpel blades, disposable syringes and needles, IV cannulas and infusion sets(11,18).

In Rwanda, the Ministry of Health has published a List of Essentials Medications for the country. The supply and distribution is centralized in the capital city. But about one third of district hospitals indicated that they have adopted the national list into one more appropriate for regional needs. Nevertheless, shortages of medications, including anesthetic medications are common. For instance, in a list of the most common “stock-outs”, diazepam is the fourth most common medication to be unavailable(12,18).

The PediPIPES score and index can be used to evaluate and compare pediatric surgical capacity in different facilities(19). Okoye and al reported mean PediPIPES indices for West African countries (actually the highest index per country) like Ghana (19.7), Burkina Faso (18.6), Ivory Coast (18.2), Nigeria (18.1), Niger (12.9), Liberia (11.4), Sierra Leone (9.4), Togo (8.9), Senegal (8.3) and Guinea (8.2). They used the indices to compare the pediatric surgical capability of the different nations, although they acknowledge that this could obscure the true hierarchy of individual countries’ performance(11).

Pediatric anesthesia and surgery in Africa have numerous problems, and information about available resources is scarce(16).

We surveyed district and referral hospitals in Rwanda to provide data on pediatric and anesthesia capacity.

Chapter 2: RESEARCH METHODOLOGY

2.1 Research design

The study used a descriptive, cross sectional survey to assess surgical and anesthesia capacity in Rwanda.

2.2 Study site description

The Rwanda Health system is decentralized and has following level of care(20):

- National referral hospitals for the provision of tertiary care to patients, teaching and research for medical and health sciences schools.
- Intermediary level consists of provincial referral hospitals with the aim to ease the workload of tertiary hospitals.
- Peripheral level consists of district health administrative unit, district hospital and a network of health centers, health posts and community health workers.

2.3 Data collection process

- The PediPIPES and WFSA AFAT tools were used to conduct the assessment.
- The Pediatric "Personnel", "Infrastructure", "Procedures", "Equipment" and "Supplies" (PediPIPES) survey tool allows the calculation of an index of surgical capacity (PIPES index). It focuses on health care facilities' ability to provide emergency surgery to infants and children, and has a total of 118 total data items. The PediPIPES defines a child as age less than 18 years(19).
- The World Federation of Societies of Anesthesiologists Anesthesia Facility Assessment (WFSA AFAT) tool aims to compile a data set that will aid in assessing national anesthesia care capacity and provide direction for achieving anesthesia safety requirements(21).
- Survey questionnaires were distributed to 40 District, 3 Provincial, 4 Tertiary referral hospitals. Nyarugenge District hospital and Ndera Hospital were excluded as only COVID-19 treatment and mental health services were provided respectively at the time of survey.
- One e-mail was sent per hospital to an identified focal person who had to be involved or working in a surgical/anesthesia department. The focal person was identified by either the Head of Anesthesia/Surgical department, Clinical Director or Director General of

contacted hospitals. Online consent for the respondent was included in the cover page of the survey.

- Data was collected for a period of 2 weeks. A reminder was sent every three days to non-respondents with a maximum of 3 attempts.

2.4 Data analysis

Data was saved in excel spreadsheet and descriptive statistics including mean, frequencies and percentages were derived from SPSS v24, IBM, Armonk, NY, US.

2.5 Ethical considerations

Ethical approval was granted by the College of Medicine and Health Sciences Institutional Review Board and by the respective institution's research review committees when requested (Appendix A).

Chapter 3: RESULTS

3.1 Demographics of responses

The overall response rate of 49% as only 23 responses were used for the analysis of results and discussion. The responses represent all the levels of care delivery in Rwanda with 100% of response rate for Tertiary and Provincial hospitals, 40% for district hospitals (Table 3. 2).

Table 3. 2: Response frequency by type of Healthcare

		Frequency	Percent	Cumulative Percent
Valid	District Hospital	16	69.6	69.6
	Provincial Hospital	3	13.0	82.6
	University Teaching Hospital	2	8.7	91.3
	Tertiary Referral Center	2	8.7	100.0
	Total	23	100.0	

Notes: Two surveyed hospitals reported as University Teaching Hospital are actually Tertiary referral centers.

3.2 Personnel

Eleven hospitals reported that neither a general surgeon nor an anesthesiologist were available. Only 2 tertiary hospitals reported a number of 20 or more general surgeons. Most hospitals had no pediatric surgeon, but reported having medical doctors doing surgery on children (Table 3. 3). Twelve hospitals reported having at least one anesthesiologist, the majority depending on nurse anesthetists with at least 2 of them present in almost all surveyed hospitals except one. Sixteen hospitals reported having at least one pediatrician available but only 6 hospitals had trained pediatric nurses available.

Table 3. 3. Frequency of hospitals with a pediatric surgeon

		Frequency	Percent	Cumulative Percent
Valid	0	19	82.6	82.6
	1	2	8.7	91.3
	2	2	8.7	100.0
	Total	23	100.0	

3.3 Infrastructure

The total number of beds in the 23 hospitals assessed ranged from 26 to 519 (Table 3. 4). The number of beds for children ranged from six to eighty (Table 3. 5)

Table 3. 4: Frequency of hospitals by total number of beds

		Frequency	Percent	Cumulative Percent
Valid	21	1	4.3	4.3
	118	1	4.3	8.7
	150	2	8.7	17.4
	170	1	4.3	21.7
	200	6	26.1	47.8
	210	1	4.3	52.2
	220	1	4.3	56.5
	230	1	4.3	60.9
	250	1	4.3	65.2
	300	2	8.7	73.9
	350	3	13.0	87.0
	409	1	4.3	91.3
	450	1	4.3	95.7
	519	1	4.3	100.0
	Total	23	100.0	

Table 3. 5: Frequency of hospitals by total number of pediatric beds

		Frequency	Percent	Cumulative Percent
Valid	6	1	4.3	4.3
	15	1	4.3	8.7
	20	2	8.7	17.4
	25	2	8.7	26.1
	30	2	8.7	34.8
	33	1	4.3	39.1
	35	2	8.7	47.8
	40	3	13.0	60.9
	41	1	4.3	65.2
	45	2	8.7	73.9
	50	3	13.0	87.0
	60	1	4.3	91.3
	65	1	4.3	95.7
	80	1	4.3	100.0
	Total	23	100.0	

Table 3. 6 summarizes the median of total surgical beds, continuously monitored beds, and ventilated ICU beds, PACU beds, number of ORs and functioning ORs.

Table 3. 6: Statistical summary of total beds and ORs

		Surgical beds	Number of continuously monitored beds	Number of ventilated ICU beds	Number of PACU beds	Number of ORs	Number of functioning ORs
Percentiles	25	16.50	0.00	0.00	2.00	2.00	2.00
	50	27.50	0.00	0.00	4.00	4.00	3.00
	75	51.00	5.75	2.75	6.00	5.00	5.00

The majority of surveyed facilities had no functioning specific pediatric ventilators (median of 0.00 (IQR). The median number of functioning newborn incubators was 5.00 (IQR, 4.00-7.00) (Table 3. 7)

Table 3. 7: Statistical summary of functioning incubators, pediatric ventilators and ORs

		Number of functioning newborn incubators	Number of functioning pediatric ventilators in ICU/NICU	Number of functioning OR
Percentiles	25	4.00	0.00	2.00
	50	5.00	0.00	2.00
	75	7.00	0.00	4.00

In terms of basic infrastructure, most of hospitals had constant access to electricity (78%), backup generator (91%). About 48% (n=11) reported running water was not always available.

Oxygen cylinders and concentrators were always available in more than 65% of surveyed facilities.

In terms of imaging, more than half hospitals had functioning X-ray (n=16) and ultrasound (n=15) machines whereas only 2 hospitals reported to have a functional CT scan machine.

3.4 Procedures and surgical volume

The total number of surgical cases performed annually per facility ranged from o to 9300 (Table 3. 8) and the total number of surgical cases on children less than 5 years from 0 to 1500.

Table 3. 8: Frequency of hospitals by total number of surgical cases

		Frequency	Percent	Cumulative Percent
Valid	0	1	5.6	5.9
	360	1	5.6	11.8
	630	1	5.6	17.6
	850	1	5.6	23.5
	950	1	5.6	29.4
	1000	1	5.6	35.3
	1500	2	11.1	47.1
	1600	2	11.1	58.8
	2000	1	5.6	64.7
	2500	1	5.6	70.6
	3500	2	11.1	82.4
	3600	1	5.6	88.2
	8080	1	5.6	94.1
	9300	1	5.6	100.0
	Total	17	94.4	

Basic procedures like wound debridement, suturing, drainage of abscess, fracture splinting male circumcision, basic laparotomy were reported done in most of surveyed hospitals. Pediatric emergencies and specialized procedures such as pyloromyotomy, bowel resection and anastomosis, removal of esophageal/airway foreign bodies, repair of intestinal/esophageal atresia, correction of spina bifida, pull-through procedures for Hirschprung's, repair of imperforated anus were reported done in less than 50% of facilities (Table 3. 9).

Table 3. 9: Summary tables of emergency and specialized procedures

Bowel resection and anastomosis

		Frequency	Percent	Cumulative Percent
Valid	Not done	14	60.9	60.9
	Done	9	39.1	100.0
	Total	23	100.0	

Removal of airway and esophageal foreign bodies

		Frequency	Percent	Cumulative Percent
Valid	Not done	12	52.2	52.2
	Done	11	47.8	100.0
	Total	23	100.0	

Pull through for Hirschsprung disease

		Frequency	Percent	Cumulative Percent
Valid	Not done	14	60.9	60.9
	Done	9	39.1	100.0
	Total	23	100.0	

Thoracotomy

		Frequency	Percent	Cumulative Percent
Valid	Not done	19	82.6	82.6
	Done	4	17.4	100.0
	Total	23	100.0	

Repair esophageal atresia

		Frequency	Percent	Cumulative Percent
Valid	Not done	21	91.3	91.3
	Done	2	8.7	100.0
	Total	23	100.0	

Repair intestinal atresia

		Frequency	Percent	Cumulative Percent
Valid	Not done	14	60.9	60.9
	Done	9	39.1	100.0
	Total	23	100.0	

Ketamine anesthesia, general anesthesia and spinal anesthesia were reported done in most surveyed hospitals but regional blocks technique were not done in 16 hospitals (70%).

3.5 Equipment and supplies

The majority of surveyed hospitals reported essential equipment like oxygen mask and tubing, stethoscope, resuscitator bad valve/mask, endotracheal tubes, laryngeal mask airway, bougies, laryngoscopes and blades, suction machine and catheters, thermometer and infant incubator, pulse oximeter, non-invasive blood pressure cuffs to be always available. Specific pediatric size equipment, equipment for neuromuscular blockade monitoring, electrocardiograph electrodes, emergency cricothyroidotomy/tracheostomy, pediatric chest tubes, tracheal tubes were reported in most of facilities as not always available/sufficient (Table 3. 10).

Table 3. 10: Summary of frequency tables of specific pediatric equipment

Paediatric pulse oximeter probe

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	1	5.6	5.6
	Rarely (1-25%)	2	11.1	16.7
	Sometimes (26-50%)	3	16.7	33.3
	Often (51-75%)	1	5.6	38.9
	Almost always (76-99%)	3	16.7	55.6
	Always (100%)	8	44.4	100.0
	Total	18	100.0	

Paediatric Laryngoscope (blade sizes 1-2)

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	1	5.6	5.6
	Rarely (1-25%)	3	16.7	22.2
	Sometimes (26-50%)	1	5.6	27.8
	Almost always (76-99%)	3	16.7	44.4
	Always (100%)	10	55.6	100.0
	Total	18	100.0	

Paediatric Laryngeal mask airways (sizes: 1, 1.5, 2)

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	2	11.1	11.1
	Rarely (1-25%)	3	16.7	27.8
	Sometimes (26-50%)	3	16.7	44.4
	Often (51-75%)	1	5.6	50.0
	Almost always (76-99%)	2	11.1	61.1
	Always (100%)	7	38.9	100.0
	Total	18	100.0	

The results showed that various disposable equipment were always (n=7, 39%) and almost always (n=4, 22%) cleaned and reused.

Surgical equipment like instrument sets, stainless steel kidney dish, autoclave, needles, syringes, IV cannulas and infusion sets were always sufficient at the majority of facilities.

Hypnotic drugs like barbiturates (propofol, thiopental) were always available in 7 hospitals (39%) and almost always available in 5 hospitals (28%), ketamine and diazepam were always available in 72% (n=13) and 61% (n=11) respectively. Midazolam was rarely or never available in half of the surveyed hospitals. Opioids (IV morphine, fentanyl) and suxamethonium are always available in more than half of surveyed hospitals. Naloxone was

always available in 44 % (n=8) Halothane was always available while isoflurane and sevoflurane were rarely and never available. Emergency drugs like atropine, adrenaline, ephedrine and oxytocin are always available in most of hospitals but amiodarone, potassium chloride, inotropes (dobutamine, dopamine, milrinone) are rarely or never available. The same is true for dantrolene and intralipid never available in 67% (n=12).

3.6 Service delivery and Information management

Most surveyed hospitals (n=13, 72%) used both electronic and paper as method of record keeping. Half of facilities reported that charts were always accessible across multiple visits for the same patients.

Monitoring standards: Continuous pulse oximetry, heart rate, non-invasive blood pressure, audible signals and alarms were always available during anesthesia. However less than 23% of surveyed facilities reported continuous wave capnography always available during anesthesia. (Table 3. 11)

Table 3. 11: How often is capnography (end tidal carbon dioxide) used continuously to monitor patients for the entire duration of anaesthesia care in the operating theatre?

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	4	22.2	22.2
	Rarely (1-25%)	3	16.7	38.9
	Sometimes (26-50%)	2	11.1	50.0
	Often (51-75%)	2	11.1	61.1
	Almost always (76-99%)	3	16.7	77.8
	Always (100%)	4	22.2	100.0
	Total	18	100.0	

Ten hospitals (55%) reported that they never or rarely provide mechanical ventilation for post-operative patients in need of ventilator support outside the theatre (Table 3. 12).

Table 3. 12: How often is this facility able to provide mechanical ventilation for postoperative patients who require ventilator support outside the operating theatres?

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	6	33.3	33.3
	Rarely (1-25%)	4	22.2	55.6
	Sometimes (26-50%)	1	5.6	61.1
	Often (51-75%)	1	5.6	66.7
	Almost always (76-99%)	3	16.7	83.3
	Always (100%)	3	16.7	100.0
	Total	18	100.0	

Most of surveyed hospitals (n=10, 57%) reported that data on post-operative adverse events were sometimes or rarely collected (Table 3. 13)

Table 3. 13: How often data are prospectively collected for patient outcomes (adverse events) postoperatively, such as surgical site infection, stroke, deep vein thrombosis (DVT), etc.?

		Frequency	Percent	Cumulative Percent
Valid	Never (0%)	1	5.6	5.6
	Rarely (1-25%)	5	27.8	33.3
	Sometimes (26-50%)	5	27.8	61.1
	Often (51-75%)	2	11.1	72.2
	Almost always (76-99%)	3	16.7	88.9
	Always (100%)	2	11.1	100.0
	Total	18	100.0	

3.7 Blood product services

Blood bank was reported always available in 21 hospitals (91%). Most hospitals (n=15, 83%) reported the ability to type and crossmatch. Packed red cells were always available in half of facilities and almost always available for the rest of surveyed hospitals.

In half of hospitals surveyed, it takes less than an hour to obtain packed red cells for emergency transfusion (Table 3. 14). Most hospitals (61%) reported that an offsite blood storage facility was the source of their blood products. Some hospitals (n=7, 39%) reported that blood products were available in less than 15 min with 2 hospitals receiving their products via a drone from the National Center for Blood Transfusion (CNTS) (Table 3. 15).

Table 3. 14: How long does it take to get packed red blood cells?

		Frequency	Percent	Cumulative Percent
Valid	<15 mins	7	38.9	38.9
	<1 hour	9	50.0	88.9
	1-5 hours	2	11.1	100.0
	Total	18	100.0	

Table 3. 15: Where do blood products come from?

		Frequency	Percent	Cumulative Percent
Valid	An off-site blood bank/storage facility	11	61.1	61.1
	Voluntary unpaid donors at this facility	5	27.8	88.9
	Drone via National Center for Blood Transfusion	2	11.1	100.0
	Total	18	100.0	

3.8 CPD, training and international cooperation

The reported frequency of CPD was daily or weekly at 7 hospitals (39%), monthly at 8 hospitals (44%).

Eleven hospitals (61%) reported presence of international partners and 14 hospitals (78%) reported receiving donation of supplies in the last year.

3.9 PediPIPES indices

The calculated mean PediPIPES index for Rwanda is 8.1 with individual hospital scores ranging from 4.8 to 14.9 (Table 3. 16). It was calculated by adding PediPIPES indices of surveyed hospitals, divided by the total number of surveyed hospitals. These indices were calculated using data from the "Personnel", "Infrastructure", "Procedure", "Equipment" and "Supply" sections of the PediPIPES assessment tool for every surveyed hospital.

Table 3. 16: PediPIPES Indices by type of health facility

Type of Healthcare facility	PediPIPES Indices
District Hospital	4.8
District Hospital	5
District Hospital	5.3
District Hospital	5.3
District Hospital	5.3
District Hospital	5.4
District Hospital	5.8
District Hospital	6.1
District Hospital	6.5
District Hospital	7.1
District Hospital	7.2
District Hospital	7.4
Provincial Hospital	7.5
Provincial Hospital	7.6
District Hospital	7.8
District Hospital	8.9
District Hospital	9.4
Provincial Hospital	9.5
District Hospital	9.9
Tertiary Hospital	12.6
Tertiary Hospital	13.4
Tertiary Hospital	13.5
Tertiary Hospital	14.9
Mean Index	**8.1**

Chapter 4: DISCUSSION

These data demonstrate a scarcity of the pediatric surgical and anesthesia personnel. A difference in the distribution throughout the country was also noted. Although some district and provincial hospitals reported to have general surgeons and anesthesiologists available, there were no pediatric surgeons available except at tertiary level of care. The findings are slightly different from a survey done previously in Rwanda which reported that no trained surgeons or anesthesiologists available at the district level(12). This implies that for optimal surgical care, children in remote areas need to get a transfer to a tertiary level. The resulting increased workload at the latter may lead to long "waiting" surgical lists, cancellation of non-urgent cases, increased family financial burden (with additional transport, accommodation fees) and unhappy patient's family.

All hospitals reported having at least one non-physician anesthetist available who is almost always independent when providing anesthesia at the level of district hospitals. The same findings were reported in another survey of Rwandan's facilities with the nation's 263 non-physician anesthetists in charge of more than (90%) of 80,000 annual anesthetics(7).

In 2018, the Rwanda Human Resource for Health (HRH) program highlighted improvement of the doctor per population ratio from 1doctor/16 001 people (in 2010) to 1/8 919 (with an increase of Rwandan specialists from 94 to 436) as well as the nurse per population ratio from 1/1 291 to 1/1 094. However, Rwanda is still below the Lancet Commission on Global Surgery (LCoGS) standards (13). With that aim, Rwanda Ministry of Health (MoH) published the "National Strategy for Health Professions Development 2020-2030" that will contribute to a more available, qualified and equitably distributed public health sector workforce(7).

WHO-WFSA standards recommended Bellwether procedures at all district hospitals, with tertiary hospital doing complex procedures like cardiac or neurosurgery(13). The results of the index study showed that only Cesarean Section was performed in almost all facilities (1 hospital reported not performing any Cesarean section), open fracture management was reported not done in 7 hospitals (39%). Laparotomies were reported to be done in more the 80% of surveyed hospital. However only simple procedures were done at the majorities like pediatric hernia repair (n=12, 52%). Most of emergency and specialized procedures were done mostly at tertiary level. This situation may be explained by the fact that at most of surveyed

district hospitals, surgery for children aged less than 5 years were carried out by general practitioners with limited skills and training. This may be associated with delayed diagnosis and inappropriate care, leading children in rural areas to lack access to emergency or specialized surgical care. From an anecdotal experience, the majority of these general practitioners are fresh Medical graduates that neither have the requisite confidence nor skill to carry out such surgical tasks. Following the foregoing challenge along with the Physician Anesthetists manpower need affect the outcome of emergency surgery in children at the district hospitals. Further research is needed to give a clearer picture of the morbidity and mortality of children undergoing emergency surgery at district and provincial hospitals in Rwanda. Similar findings were observed in a survey done in Democratic Republic of Congo, which reported that wound treatment operations (such as drainage of abscess, suturing, wound debridement), fracture splinting, male circumcision, basic laparotomy, appendectomy and pediatric hernia repair were among the most commonly done procedures at all assessed institutions (n=14)(22).

Although basic infrastructure such as oxygen, running water, external electricity, functioning backup generators, incinerator, functioning x-ray and ultrasound machines, emergency department are almost always available, this survey highlighted a scarcity in post-operative care unit, general and pediatric ICU. One surveyed hospital even reported no PACU was available at all, yet surgeries are being done. This inability to provide postoperative ventilation outside the theatre is one of major cause of postponement of specialized, elective pediatric surgeries and increase the perioperative morbidity and mortality for complex emergent or urgent pediatric surgeries. This is also true for tertiary hospitals as the number of functioning pediatric ventilators in ICU/NICU varies from a minimum of 3 to a maximum of 7 (Table 6). In Malawi, research indicated that more than 75% of district hospitals assessed lacked the minimum facilities needed to deliver surgical services. They complained about a lack of reliable running water, electricity, or a working backup generator(23).

Although this present study showed the availability of most basic equipment needed for surgery and anesthesia, a notable exception was the report that specific pediatric size equipment are sometimes available. This is the common reason for cleaning and reuse of pediatric airway equipment that become less efficient with the increasing frequency of reuse. The same findings were observed in the study done in Mongolia stating that provincial

hospitals are well equipped but lacked pediatric specific disposables (endotracheal tubes and endoscopes)(17). Another study in Burundi determined that 50 (91%) of hospitals had at least one anesthesia machine, respondents for 17 out of the 50 (34%) hospitals reported that their machines were not functional and 9 out of the 50 (18%) hospitals reported their machines being partially functional. Furthermore the latter specified that the ventilator feature did not work. Capnography was reported by nine (16%) of hospitals(24).

Concerning monitoring during anesthesia, our study showed that capnography was rarely available or used in most provincial and district hospitals. Capnography helps to recognize esophageal intubation and thus saving lives as approximately 11,000 deaths per year from esophageal intubation are reported(25). WHO-WFSA International Standards highly recommend colorimetric capnography during anesthesia for confirmation of the correct placement of endotracheal tubes(13).

Over 50% of the hospitals reported that data on post-operative adverse reactions were sometimes or rarely collected. These are important data to be used for quality improvement and morbidity and mortality meetings. Experience has shown that this may be due to the limited personnel and still high volume of surgical patients (ranging from 360 to 9300 cases per hospital per year). Only 6 hospitals (33%) answered that a person trained to administer analgesic and assess airway and hemodynamic compromise, was always physically present in the PACU/recovery room. Continuous monitoring in PACU, pulse oximetry and Non-invasive blood pressure, was reported to be always available respectively in 7 (39%) and 9 (50%) surveyed hospitals. This issue may be address by increasing the workforce as well as regular training of staff in perioperative monitoring.

Although most of essential medications for safe anesthesia were always or almost always present in all surveyed hospitals, emergency drugs like amiodarone, potassium chloride, dantrolene and intralipid are rarely or never available. The same was observed in a prospective observational study at Konfo Anokye Teaching Hospital (KATH) in Ghana where the majority of recommended drugs were available with the exception of pancuronium, some IV antiarrhythmic drugs and IV nitroglycerin(18,26). This makes it difficult to treat rare but fatal complications like malignant hyperthermia, unstable arrhythmias perioperatively in Rwanda.

This index study highlighted one of the innovative ways of using drone service in delivering essential health supplies in countries with limited resource. The drone is operated by a California-based company, Zipline, focused on delivering medical supplies in areas with poor infrastructure. Blood request is done by whatsapp and the shipment usually reach destination in less than 15 minutes. This is a timely service that has solved prior technical and logistics issues (short shelf life and strict storage requirements about blood and blood products) associated with road delivery, especially in a country like Rwanda where it can take up to 5 hours for some hospitals. The Zipline initiative in Rwanda has improved the outcome of patients in need of emergency transfusion and could serve as a model for Africa(27,28). However, half of the survey hospitals reported average time for availability of emergency to be less than an hour and 2 hospitals reported a time between 1-5 hours (Table 3.14). This highlights that the drone delivery service is not yet implemented in all hospitals in remote area in Rwanda. There is a need to develop national projects and improve local infrastructure that aim at improving blood product service delivery in Rwanda. A study in Liberia reported that, in a half of surveyed hospitals, blood delivery can take between 1 and 5 hours in an emergency request (with one facility reporting a time of 10-24 hours)(4).

The mean PediPIPES index for Rwanda was 8.1, with values ranging between 4.8 (lowest) and 14.9 (highest). The highest scores were seen in tertiary level of care but more variability was observed for both district and provincial hospitals. The mean PediPIPES index for Rwanda is close to the mean of 7.7 calculated for DRC(22). West African countries indices reported in Okoye's study represented the highest score for individual hospitals in the country(11). The low mean PediPIPES index for Rwanda can be explained by low "Personnel", "Procedures" and 'Infrastructure" scores noted especially when assessing district and provincial hospitals highlighting that much effort is needed for those specific levels of care.

This present study is limited by a small sample size representing about 49% of response rates. Fortunately, all levels of care were represented. The findings from two different capacity analysis tools were merged due to lack of a national pediatric surgical and anesthesia capacity assessment tool. The PediPIPES tool is designed for pediatric surgical and anesthetic capacity assessment, however it does not include training capacity, quality assurance measures like morbidity and mortality, or research. This gap was less in this study with the association of the

WFSA AFAT tool. Both tools, however, provide less information on neonatal specific questions.

Chapter 5. CONCLUSION AND RECOMMENDATIONS

This is the first survey of pediatric surgical and anesthesia capacity of district, provincial and tertiary hospitals in Rwanda. Despite its limitation, results from this survey highlighted areas of severe deficiency in pediatric perioperative care, both human and material resources

Following recommendations are suggested:

- To enhance national training programs to increase the health care workforce especially those dedicated to pediatric surgery and anesthesia. We highly support the Rwandan "National Strategy for Health Professions Development 2020-2030". Meanwhile increasing direct supervision at lower level of care (provincial and district) of medical doctors doing surgeries on children as well as non-physician anesthesia providers, creation and implementation of local standard guidelines and protocols to guide practice.
- To improve perioperative mortality rate tracking as well as collection of data about post-operative adverse outcomes as highly recommended by WHO standards for safe anesthesia and surgical care
- To advocate for more infrastructure dedicated to pediatric surgery (like construction of fully equipped Kids OR) and critical care to allow more complex procedures and improve overall outcome.
- To develop national surgical and anesthesia capacity assessment tools as well and advocate for more funding of research with the aim of improving pediatric perioperative care.

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APPENDIX A: IRB Approval

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 22nd /June /2021

Mutembe Nzobele Bruce,
School of Medicine and Pharmacy, CMHS, UR

Approval Notice: No 228/CMHS IRB/2021

Your Project Title ***"Pediatric Surgery and Anesthesia Capacity in Rwanda: a Survey of District and Referral Hospitals"*** has been evaluated by CMHS Institutional Review Board.

Name of Members	Institute	Involved in the decision		
		Yes	No (Reason)	
			Absent	Withdrawn from the proceeding
Prof Kato J. Njunwa	UR-CMHS	X		
Dr Stefan Jansen	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS		X	
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 18th June 2021, **Approval has been granted to your study.**
Please note that approval of the protocol and consent form is valid for **12 months**.

APPENDIX B: PediPIPES TOOL

The PIPES survey assesses gaps in the availability of essential and emergency surgical care (EESC) at resource constrained health facilities. This novel survey originated as the WHO Tool for Situational Analysis, and was subsequently modified by Surgeons OverSeas (SOS) to include absolute numbers of hospital beds and operating rooms; a binary system of measurement to enable easier counting of items; omitting reasons for not performing procedures; and restructuring and streamlining of individual questions. The data items were divided into five sections: Personnel, Infrastructure, Procedures, Equipment and Supplies (PIPES), and permitted the derivation of an index of surgical capacity (PIPES index). This PediPIPES survey focuses on the capacity of health facilities to provide EESC to infants and children, and has 118 total data items compared to the 256 of the WHO tool. In this survey, a child is defined as age ≤ 18 years

COUNTRY:	
Interviewer: Name/contact info	
Health Care Facility: Name/address	
Phone interview or site visit:	
Respondent: Name/contact info:	
Type of Healthcare Facility: (Health Center, District, Secondary, Tertiary, Univ, Private, NGO, Mission)	
Hospital beds (total numbers)	
Hospital Beds (Pediatric)	
PERSONNEL (7)	**Total number**
Pediatric surgeon	
General surgeon	
Medical doctors (doing surgery on children)	
Pediatricians	
Pediatric trained nurses	
Anesthesiologists (MD)	
Nurse anesthetists	
TOTAL P-score: (add all the numbers of Personnel)	

INFRASTRUCTURE (14)	**Always available (1)**	**Not always available (0)**
Running water?		
External electricity?		
Functioning back-up generator?		
Incinerator?		
Medical records?		
Emergency department?		
Postoperative care area?		
Special Care Baby Unit		
Neonatal Intensive Care Unit (NICU) or General ICU?		
Pretested blood available (blood bank)?		
Lab to test blood and urine?		
Functioning X-ray machine?		

Functioning ultrasound machine?		
Functioning CT scan?		
Sub TOTAL I score: (give 1 point to each available)		
# of functioning newborn incubators:		
# of functioning pediatric ventilators in ICU/NICU:		
# of functioning operating rooms:		
TOTAL I-score: (add subtotal + # incubators + # pediatric ventilators + # operating rooms)		

PROCEDURES (46)	**Done (1)**	**Not done (0)**
Resuscitation		
Suturing		
Wound debridement		
Incision & drainage of abscess		
Laparotomy		
Tracheostomy		
Chest tube insertion		
Burn management		
Non-operative Reduction of intussusception		
Appendectomy		
Removal of airway and esophageal foreign bodies		
Bowel resection and anastomosis		
Male circumcision		
Skin grafting		
Pediatric hernia repair		
Pediatric abdominal wall defects		
Repair Imperforate anus		
Ladd procedure		
Orchiopexy		
Rectal biopsy		
Pullthrough for Hirschsprung disease		
Repair of testicular torsion		
Resection solid abdominal mass		
Thoracotomy		
Insertion G-tube		
Repair esophageal atresia		
Repair intestinal atresia		
Creation Intestinal stomas		
Closure intestinal stomas		
Repair imperforate hymen		
Pyloromyotomy		
Ovarian cystectomy		
Fracture Splinting		
Casting for Fracture		

Traction (closed fracture)		
Treatment of Open Fracture		
Management of Osteomyelitis		
Amputation		
Non-operative treatment of Clubfoot		
Contracture release		
Laparoscopic surgery		
Repair Spina Bifida		
Regional anesthesia blocks		
Spinal anesthesia		
Ketamine anesthesia		
General anesthesia		
TOTAL Pr-score: (add all procedures done)		

Equipment (22)	**Always available (1)**	**Not always available (0)**
Oxygen: compressed (cylinder)		
Oxygen: concentrator		
Resuscitator bag valve & mask (paediatric)		
Oropharyngeal airway (paediatric)		
Endotrachael tubes (pediatric)		
Anesthesia machine		
Pulse oximeter		
Oxygen mask & tubing		
Stethoscope		
Blood pressure measuring equipment (Pediatric cuffs)		
Thermometer		
Weighing Scale (Infant)		
Surgical Instrument sets (abdominal)		
Kidney dish stainless steel		
Sterilizer (autoclave)		
Suction pump (manual or electric)		
Electrocautery machine		
Apneic alarm detector/Apnea monitor		
Syringe pumps		
Neonatal T-piece (e.g. Jackson Rees)		
Endoscopes (any of esophagoscope/bronch/cysto)		
Operating room lights		
TOTAL E-score: (add all Equipment available)		

SUPPLIES (26)	**Always available/ sufficient (1)**	**Not always available/ sufficient (0)**
Gloves (sterile)		
Gloves (examination)		

Nasogastric tubes 12F or smaller		
Intravenous fluid infusion sets		
Blood transfusion sets		
IV cannulas		
Syringes		
Disposable needles		
Tourniquet		
Sterile gauze		
Bandages sterile		
Adhesive Tape		
Suture (absorbable)		
Suture (non-absorbable)		
Urinary catheters (must include 6F)		
Sharps disposal container		
Scalpel blades		
Face masks		
Eye protection (goggles, safety glasses)		
Apron		
Boots (theatre shoes)		
Gowns (for surgeon/scrub nurse)		
Drapes (for operations)		
Chest tubes 12F or smaller		
Trach tubes		
Laparoscopic supplies		
Total S-score: (add all supplies sufficient available)		

A total PediPIPES score is calculated by summing the number of the Personnel, Infrastructure and number of operating rooms, Procedure, Equipment and Supplies scores. This number was then divided by the total number of data items (118) and multiplied by 10 to create the PediPIPES index. There is no maximum number for the PediPIPES index.

P-score: (no maximum)
I-score: (maximum XX plus # of functioning incubators, pediatric ventilators, and ORs)
Pr-score: (maximum of XX)
E-score: (maximum of XX)
S-score: (maximum of XX)

TOTAL PediPIPES SCORE:

Divide the total score by 118 and multiply by 10 for the PIPES-index: (TOTAL PediPIPES SCORE / 118) x 10 =

Questions regarding PediPIPES or access to an iPad application can be forwarded to: reinou@humanitariansurgery.org

APPENDIX C: WFSA AFAT TOOL

WFSA Anaesthesia Facility Assessment Tool (AFAT) v1.1

This questionnaire is based on multiple prior efforts to assess surgical and anaesthesia capacity including: The Harvard Humanitarian Initiative Tool[1], the "International Standards for a Safe Practice of Anaesthesia" most recently revised by the World Federation of Societies of Anaesthesiologists (WFSA) in 2010[2], the World Health Organization Tool for Situational Analysis to Assess Emergency and Essential Surgical Care[3], the World Health Organization (WHO) and Harvard Program for Global Surgery and Social Change (PGSSC) Surgical Assessment Tool (SAT) for Hospital Walkthrough[4], the Surgeons Overseas (SOS) PIPES Surgical Capacity Assessment tool[5], the Lancet Commission on Global Surgery[6], the WHO-WFSA International Standards for a Safe Practice of Anaesthesia 2017, and multiple national anaesthesia capacity assessment projects using other tools[7,8].

The purpose of this questionnaire is to create a data set to help evaluate capacity for anaesthesia care at a national level, and to provide guidance for improving or maintaining standards for the safe practice of anaesthesia. Completion of this survey is **voluntary** and **optional.** This form is intended to be completed by an anaesthesia provider. Ideally, this provider should have first-hand knowledge of the facility that is being reviewed. Data collection must be done in accordance with local protocols and laws, and must not include any patient health information. Providing your personal contact information is optional and would only be used if clarification of your responses is needed.

Data may be entered electronically using an online version of this survey form. Data are stored in a secure RedCap database, jointly maintained by the WFSA and the UCSF Anesthesia Division of Global Health Equity. If you enter data electronically, you will be provided a copy of your survey responses as a pdf and as a raw database file. More information on the electronic survey tool can be found at the WFSA website.

This survey should take approximately 45 minutes. If you are **unsure** of the answer to any question or choose not to answer, please **leave it blank**. You may stop the survey at any time.

GENERAL QUESTIONS	
Date of data collection (dd/mm/yy):	
Contact information of staff completing this assessment (Name, phone and email):	
Country (location of healthcare facility being surveyed):	
Healthcare facility name:	
Healthcare facility region/district:	
Healthcare facility address, including city/town:	

Which of the following terms best describes this healthcare facility? (Select one)	Health Centre/Clinic District Hospital/First Referral Hospital Provincial or Secondary/Regional Referral Hospital Tertiary or National Referral Hospital
Which of the following terms best describe this healthcare facility? (Select all that apply)	Public Private NGO/Mission/Charity facility University hospital

What is the profession of the person providing information to complete questionnaire?

Physician (specialist) anaesthesiologist: A graduate of medical school who h a s completed a *nationally recognized* specialist anaesthesia training program/residency

Non-specialist physician anaesthetist: A graduate of medical school who has not completed a specialist training program/residency in anaesthesia but has undergone some formal a anesthesia training

Nurse anaesthetist: A graduate of a nursing school who has also completed a *nationally recognized* nurse anaesthetist training program

Non-physician, non-nurse anaesthetist: An anaesthesia provider with no nursing degree, but who has completed a *nationally recognized* anaesthetist training program

Other: _____

For how many years have you worked at this facility?	<1 year 1-3 years I have never worked at this facility >3 years

INFRASTRUCTURE

How many total inpatient beds does this healthcare facility have?	<50 50-99 100-299 300-499 500-999 >999
Does this facility have an intensive care unit (ICU) or high-dependency unit (HDU)?	Yes No
How many intensive care unit (ICU) or high-dependency unit (HDU) beds does this facility have that can provide mechanical ventilation?	#

How many intensive care unit (ICU) or high-dependency unit (HDU) beds does this facility have that can provide continuous monitoring?	#
Does this facility have an inpatient surgical ward?	Yes No
a. If yes to the question above, how many patient beds are in the surgical ward?	#
Does this facility have a post-anaesthesia care unit (PACU) or recovery room (where patients remain while recovering from anaesthesia before going back to the inpatient ward or being discharged if day surgery)?	Yes No
a. If yes to the question above, how many patient beds are in the PACU/recovery room?	#

	Total #	***Functioning #** Functioning is defined as in working condition and can be used for patient care
How many operating theatres/rooms does this health facility have? (*This includes operating theatres in the main operating theatre complex as well as remote theatres like obstetrics/gyn, accident & emergency, orthopaedics, etc.*)	#	#

How often are you able to access Internet that is provided by this facility?	**Always** (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
How often is oxygen available?	**Always** (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
How often is running water available?	**Always** (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
How often is electricity available?	**Always** (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)

How often does this facility offer continuing medical education (CME) or continuing professional development (CPD) to the staff?	**Daily/ Weekly**	**Monthly**	**Quarterly**	**Annually**	**Never**

Have any international organizations or institutions (NGO's, universities, non-profits etc.) worked, volunteered or partnered with this facility in the past 1-year? Yes No
If yes to question above, please list the names of these organizations:
Has this facility received donations of supplies (including medications, equipment, or disposables) from any international organizations or institutions (NGOs, universities, non-profits etc.) in the past 1-year? Yes No

BLOOD PRODUCT SERVICES						
Are blood transfusions performed at this facility? (If "No" you may proceed to the next section "Information Management")	Yes No					
	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
How often can this facility test blood products for blood type (i.e. ABO/Rh type) *and* perform a crossmatch?						
How often is <u>whole blood</u> available to patients at this facility?						
How often are units of <u>packed red blood cells</u> available to patients at this facility?						
How often is <u>plasma</u> available to patients at this facility?						
How often are <u>platelets</u> available to patients at this facility?						
Approximately how long does it take to obtain red blood cells (whole blood or packed red blood cells) in an emergency?	<15 minutes 5-10 hrs	<1 hour 10-24 hrs	1-5 hrs >24 hr s			

What is the primary source of blood used by this facility? (Select one)	Voluntary unpaid donors at this facility Paid donors at this facility Patient family donors at this facility An off-site blood bank/storage facility Other

INFORMATION MANAGEMENT

What is the method of record keeping in this hospital?	Electronic Paper Both None					
	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
How often are charts accessible across multiple visits for the same patient?						
How often are the details of each anaesthetic (including: preoperative assessment, anaesthetic plan, intraoperative and postoperative management) documented in an anaesthesia record?						
How often are surgical cases that are done in the operating theatres recorded in a theatre book or logbook?						

How often are data prospectively collected for patient outcomes (adverse events) postoperatively, such as surgical site infection, stroke, deep vein thrombosis (DVT), etc?						
How often does this facility conduct morbidity & mortality reviews for quality improvement?	As needed	Daily/Weekly	Monthly	Quarterly	Annually	Never
How often is this facility required to report morbidity & mortality information to the Ministry of Health or an equivalent agency?	As needed	Daily/Weekly	Monthly	Quarterly	Annually	Never

[2]**Non-specialist physician anaesthetist** - a graduate of a medical school who has not completed a specialist training program/residency in anaesthesia but has undergone some formal anaesthesia

WORKFORCE

How many of the following providers are currently employed by this health facility? *(If unsure please leave blank; **if none please indicate "0"**)*

	Full-Time	Part-Time
Anaesthesia services		
Physician (specialist) anaesthesiologists[1]	#	#
Non-specialist physician anaesthetists[2]	#	#
Nurse anaesthetists[3]	#	#
Non-physician, non-nurse anaesthetists[4]	#	#
Other anaesthesia providers[5]	#	#
Surgical services		
Physician surgeons	#	#
General (non-specialist) physicians who provide surgery	#	#
Non-physicians who provide surgery	#	#
Obstetrics/gynaecology services		
Obstetrician/gynaecologists (physicians)	#	#
General doctors who provide C-sections	#	#
Non-physicians who provide C-sections	#	#
Midwives	#	#
Other services		
Biomedical engineers or technicians	#	#
Theatre (scrub) nurses	#	#

How often are the following providers available for clinical care at this health facility?	Always (100%)	Almost always (76-99%)	Often (51-75%)	Sometimes (26-50%)	Rarely (1-25%)	Never (0%)
Physician (specialist) anaesthesiologist[1]	☐	☐	☐	☐	☐	☐
Anaesthesia residents/trainees	☐	☐	☐	☐	☐	☐
Non-specialist physician anaesthetists[2]	☐	☐	☐	☐	☐	☐
Nurse anaesthetists[3]	☐	☐	☐	☐	☐	☐
Non-physician, non-nurse anaesthetists [4]	☐	☐	☐	☐	☐	☐
Other anaesthesia providers[5]	☐	☐	☐	☐	☐	☐
Surgical provider (Physician or non-physician)	☐	☐	☐	☐	☐	☐
Obstetrician/Gynaecology provider (Physician or non-physician)	☐	☐	☐	☐	☐	☐
Theatre (scrub) nurses	☐	☐	☐	☐	☐	☐
How often are non-physician anaesthesia providers at this facility supervised onsite by physician anaesthesiologists?	☐	☐	☐	☐	☐	☐

Do physician anaesthesiologist trainees work at this facility as part of their training?	☐ Yes ☐ No					
Do non-physician anaesthetist trainees work at this facility as part of their training?	☐ Yes ☐ No					
On average, what is the approximate nursing provider to patient ratio in the ICU/HDU?	☐ 1:1-	☐ 1:3-4	☐ 1:4-5	☐ 1:5-10	☐ <1:10	☐ NA
On average, what is the approximate nursing provider to patient ratio in the surgical ward?	☐ 1:1-	☐ 1:3-4	☐ 1:4-5	☐ 1:5-10	☐ <1:10	☐ NA
At any given time, what is the approximate care provider to patient ratio in the PACU/recovery room?	☐ 1:1-	☐ 1:3-4	☐ 1:4-5	☐ 1:5-10	☐ <1:10	☐ NA

[1]**Physician (specialist) anaesthesiologist** - graduate of a medical school who has completed a *nationally recognized* specialist anaesthesia training program/residency training [3]**Nurse anaesthetists** - a graduate of a nursing school who has also completed a *nationally recognized* nurse anaesthetist training program

[4]**Non-physician, non-nurse anaesthetists** - anaesthesia provider with no nursing degree, but who has completed a *nationally recognized* anaesthetist training program

Other anaesthesia provider - a provider who does not fit within any of the aforementioned definitions

SERVICE DELIVERY

	Always (100%)	Almost always (76-99%)	Often (51-75%)	Sometimes (26-50%)	Rarely (1-25%)	Never (0%)
How often are patients evaluated by an anaesthesia professional (physician or non-physician with nationally recognized anesthesia training) prior to administration of anaesthesia?	☐	☐	☐	☐	☐	☐
How often is the WHO Surgical Safety Checklist (or locally-modified version) used in the operating room prior to each surgical case?	☐	☐	☐	☐	☐	☐
When indicated, how often are prophylactic antibiotics given prior to skin incision in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is continuous pulse oximetry used to monitor patients for the entire duration of anaesthesia care in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is capnography (end tidal carbon dioxide) used continuously to monitor patients for the entire duration of anaesthesia care in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is a circuit "disconnect alarm" utilized during mechanical ventilation?	☐	☐	☐	☐	☐	☐
How often is the patient's circulation continuously monitored either by palpation, auscultation, or display (on a monitor) of the heart rate for the entire duration of anaesthesia care in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is blood pressure measured at least every 5 minutes while providing anaesthesia?	☐	☐	☐	☐	☐	☐
For cases requiring general or neuraxial anaesthesia, how often is a designated anaesthesia provider (other than the surgeon) continuously present inside the operating theatre with the patient?	☐	☐	☐	☐	☐	☐
How often are audible monitor signals and alarms available AND on at all times in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is there capability for measurement of inspired/expired volatile gas concentration in the operating theatre?	☐	☐	☐	☐	☐	☐
How often is this facility able to provide mechanical ventilation for postoperative patients who require ventilator support outside the operating theatres?	☐	☐	☐	☐	☐	☐
How often is a trained assistant (e.g. operating room nurse or technician) available to assist the anaesthesia provider in theatre?	☐	☐	☐	☐	☐	☐
Is there a "handover protocol" for transfer of care from one anaesthesia provider to another in the operating theatre?	☐ Yes ☐ No					
How often are pain scores assessed by a healthcare provider in the first 24-hours post-operation?	☐ Hourly	☐ Once every 2-4 hrs	☐ Once every 4-6 hrs	☐ Once every 6-12 hrs	☐ Once every 12+ hrs	☐ Never

If this facility does not have a PACU/recovery room, skip the next 6 questions.	Always (100%)	Almost always (76-99%)	Often (51-75%)	Sometimes (26-50%)	Rarely (1-25%)	Never (0%)
When patients are present in the PACU/recovery room, how often are personnel trained to administer analgesic medications AND recognize airway and hemodynamic compromise physically present in the PACU/recovery room?	☐	☐	☐	☐	☐	☐
How often is continuous pulse oximetry available for continuously monitoring a patient for the entire duration of care in the PACU/recovery room?	☐	☐	☐	☐	☐	☐
How often is NIBP measurement available for all patients in the PACU/recovery room?	☐	☐	☐	☐	☐	☐
How often is oxygen immediately available in the PACU/recovery room?	☐	☐	☐	☐	☐	☐
How often is suction immediately available in the PACU/recovery room?	☐	☐	☐	☐	☐	☐
How often is a self-inflating bag-mask immediately available in the PACU/recovery room?	☐	☐	☐	☐	☐	☐

Are open fractures surgically repaired at this health facility?	☐ Yes ☐ No
Are laparotomies (e.g. uterine rupture, ectopic pregnancy, acute abdomen, intestinal perforation, traumatic injuries) performed at this health facility?	☐ Yes ☐ No
Are Caesarean sections performed at this health facility?	☐ Yes ☐ No
Are surgical cases performed on children (age < 5 years old) at this health facility?	☐ Yes ☐ No
Is epidural anaesthesia performed at this facility?	☐ Yes ☐ No

LOGBOOK QUESTIONS ABOUT SURGICAL CASES

Please use the theatre logbook and/or morbidity and mortality logbook/data to answer the following section. If you do not have access to the logbook, please leave these questions blank.

How many **total surgical cases** were performed in the operating theatres of this facility in the past 12 months?	#
How many **post-operative,** in-hospital deaths occurred (i.e. deaths before discharge in patients who have undergone a surgical procedure in the operating theatre) at this facility in the past 12 months?	#
How many **intraoperative** deaths (i.e. deaths in theatre) occurred at this facility in the past 12 months?	#
How many open fracture repairs were performed at this facility in the past 12 months?	#
How many laparotomies (e.g. uterine rupture, ectopic pregnancy, acute abdomen, intestinal perforation, traumatic injuries) were performed at this facility in the past 12 months?	#
How many Caesarean sections were performed at this facility in the past 12 months?	#
How many surgical cases were performed on children (age < 5 years old) at this facility in the past 12 months?	#

MEDICATIONS

How often are the following medications available when needed for anaesthesia, surgical, or analgesia care at this facility?

	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
Ketamine IV/IM						
Meperidine (pethidine) IV/IM						
Morphine IV/IM						
Morphine PO						
Nalbuphine IV/IM						
Paracetamol (acetaminophen) IV or PO						
NSAIDs IV or PO						
Fentanyl IV						
Tramadol PO						
Oxycodone PO						
Codeine PO						
Methadone PO						
Gabapentin PO						
Lidocaine 1% or 2% IV/SQ						
Lidocaine 5% intrathecal						
Bupivacaine intrathecal						
Diazepam IV/IM						

Midazolam IV						
Naloxone IV						
Propofol IV						
Thiopental IV						
Nitrous Oxide						
Isoflurane						
Halothane						
Sevoflurane						
Ether						
Succinylcholine (Suxamethonium) IV/IM						
Rocuronium IV						
Vecuronium IV						
Cisatracurium IV						
Pancuronium IV						
Atracurium IV						

MEDICATIONS (continued)

How often are the following medications <u>available when needed</u> for anaesthesia/surgical or analgesia care at this facility?

	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
Neostigmine IV						
Hydralazine IV						
Furosemide IV						
Dextrose 50% IV						
Aminophylline IV						
Hydrocortisone IV						
Ergometrine IV/IM						
Metaraminol IV/IM						
Epinephrine IV/IM						
Atropine IV						
Ephedrine IV						
Phenylephrine IV						
Norepinephrine IV						
Dopamine IV						

Dobutamine IV						
Milrinone IV						
Amiodarone IV						
Magnesium IV						
Nitroglycerin IV						
Calcium chloride IV						
Potassium chloride IV						
Oxytocin IV/IM						
Misoprostol PO or intravaginal						
Dantrolene IV						
Intralipid IV (for local anaesthetic toxicity)						
Mannitol IV						
Tranexamic acid (TXA) IV						
Insulin IV or SQ						

EQUIPMENT

For the following pieces of equipment, please indicate the total number that are present at this facility and are designated for anaesthesia/surgical care in the operating theatres (i.e. the total # for all operating theatres). *Do not include equipment personally owned by providers.

Pulse oximeters	#
Laryngoscopes	#
Non-invasive blood pressure monitors	#

How often are the following equipment <u>available and in functioning*</u> <u>condition</u> when needed for anaesthesia or surgical care in the operating theatres?
(*Functioning is defined as in working condition and can be used for patient care)

	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
Adult self-inflating breathing bag/mask						
Paediatric self-inflating breathing bag/mask						
Manual or electric suction pump						
Stethoscope						
Thermometer						
Pulse oximeter						
Adult pulse oximeter probe						
Paediatric pulse oximeter probe						

EQUIPMENT (continued)

How often are the following equipment available and in functioning* condition when needed for anaesthesia or surgical care in the operating theatres?

(*Functioning is defined as in working condition and can be used for patient care)

	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
Portable oxygen concentrator						
Oxygen tanks with tubing						
Central oxygen generation plant						
Adult Laryngoscope (blade sizes 3-4)						
Paediatric Laryngoscope (blade sizes 1-2)						
Bougies						
Eye protection for staff						
IV infusion/drug injection equipment						
Suction catheters (e.g. Yankauer suckers)						
Adult Endotracheal tubes (sizes: 6.0-8.0)						
Paediatric Endotracheal tubes (sizes: 3.0-5.0)						
Adult Laryngeal mask airways (sizes: 3, 4, 5)						
Paediatric Laryngeal mask airways (sizes: 1, 1.5, 2)						
Oral airways adult size						
Oral airways paeds size						
Nasal airways						
Operational power generator						
Functioning Autoclave						
Hand sanitizer or soap						
Glucose measurement device						
Haemoglobin measurement device						
Supplies for emergency cricothyroidotomy/tracheostomy						
Functioning ultrasound machine						
Functioning X-ray machine						
Refrigerator for medications						
Air conditioning in operating theatre						
Operating table with tilting function						
Work surface for meds in theatre						

Intra-arterial blood pressure monitor						
Automatic, non-invasive blood pressure monitor						
Manual, non-invasive blood pressure cuff						
Neuromuscular transmission monitor (for assessing neuromuscular block)						
Adequate operating theatre lighting						
Volatile anaesthetic vaporizers						
Bellows or bag to inflate lungs						
Face masks of various sizes						
O2 supply failure alarm; inspired oxygen analyzer						
Continuous waveform capnography						
Spot check capnography						
Defibrillator						
Electrocardiograph monitor						
Electrocardiograph electrodes						
IV pressure infuser bag						
Isotonic crystalloid IV fluid						
IV Cannulas (18g, 20g, 22g, and 24g)						
Magill forceps						
Nasogastric tubes (10-16F)						

EQUIPMENT (continued)

How often are the following equipment available and in functioning* condition when needed for anaesthesia or surgical care in the operating theatres?

(*Functioning is defined as in working condition and can be used for patient care)

	Always (100%)	**Almost always** (76-99%)	**Often** (51-75%)	**Sometimes** (26-50%)	**Rarely** (1-25%)	**Never** (0%)
Catheter for bladder catheterization						
Spinal needles (22g, 25g)						
Peripheral nerve stimulator (for regional anaesthesia)						
Epidural placement supplies						
Sterile gloves						
Examination gloves (non-sterile)						
Syringes						
Infusion pumps						

Electric warming blanket						
Infant incubator						
Adult anaesthesia breathing circuits						
Paediatric anaesthesia breathing circuits						
Water Traps						
Sterilizing skin preparation solution						
Blood gas analyzer						
How often is disposable equipment used, then cleaned and reused (e.g. endotracheal tubes, LMAs, etc)?						
How often do anaesthesia providers at this facility use their own (personally owned) equipment?						
How often can non-functioning equipment (suction machines, vitals monitors, autoclaves) be repaired onsite by staff at this facility?						
How many anaesthesia machines are available at this health facility?	Total #:			Total # functioning & available for use:		
How many mechanical ventilators are present outside of the operating theatres in this facility?	Total #:			Total # functioning & available for use:		

COMMENTS

Please provide any additional comments or concerns below:

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