World J Surg (2012) 36:1056–1065
DOI 10.1007/s00268-012-1482-7

World Journal of Surgery

Challenges of Surgery in Developing Countries: A Survey of Surgical and Anesthesia Capacity in Uganda's Public Hospitals

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Published online: 9 March 2012

Abstract

Background There are large disparities in access to surgical services due to a multitude of factors, including insufficient health human resources, infrastructure, medicines, equipment, financing, logistics, and information reporting. This study aimed to assess these important factors in Uganda's government hospitals as part of a larger study examining surgical and anesthesia capacity in low-income countries in Africa.

Methods A standardized survey tool was administered via interviews with Ministry of Health officials and key health practitioners at 14 public government hospitals throughout the country. Descriptive statistics were used to analyze the data.

Results There were a total of 107 general surgeons, 97 specialty surgeons, 124 obstetricians/gynecologists (OB/GYNs), and 17 anesthesiologists in Uganda, for a rate of one surgeon per 100,000 people. There was 0.2 major operating theater per 100,000 people. Altogether, 53% of all operations were general surgery cases, and 44% were OB/GYN cases. In all, 73% of all operations were performed on an emergency basis. All hospitals reported unreliable supplies of water and electricity. Essential equipment was missing across all hospitals, with no pulse oximeters found at any facilities. A uniform reporting mechanism for outcomes did not exist.

Conclusions There is a lack of vital human resources and infrastructure to provide adequate, safe surgery at many of the government hospitals in Uganda. A large number of surgical procedures are undertaken despite these austere conditions. Many areas that need policy development and international collaboration are evident. Surgical services need to become a greater priority in health care provision in Uganda as they could promise a significant reduction in morbidity and mortality.

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Introduction

Globally, two to three billion people lack access to adequate surgical services [1]. This is not due to lack of demand as an estimated 11% of disability adjusted life years (DALYs) are from surgical conditions [2]. Instead, it is a result of a multiplicity of factors including insufficient

health human resources and management, absent or deficient infrastructure, lack of essential medicines and equipment, underfinancing, poor logistics, and inadequate information reporting systems. As a result, the poorest 35% of the world's population undergo only 3.5% of all surgical procedures performed annually [3]. Uganda falls within this victimized population. The true capacity to fulfill the surgical demand of the country is currently unknown.

Country overview

Uganda is a land-locked country straddling the equator in eastern Africa. It is bordered by Kenya to the east, South Sudan to the north, the Democratic Republic of Congo to the west, Rwanda to the southwest, and Tanzania to the south. The country is 241,040 km^2 and currently has a population of 32,709,865 people [4]. With a total fertility rate of 6.7 births per woman—the second highest in the world—Uganda is due to double its population (starting with 2,006 numbers) by 2037 [5]. The capital, Kampala, is a city of 1.4 million people located in the south-central region of the country.

Despite achieving 5.8% gross domestic product (GDP) growth rate in 2010, almost one-third of the country still lives in poverty (defined as living on less than US $1.25/day) [4]. A total of 85% of the population live in rural areas, and most of them work in the agriculture sector [6]. Uganda ranks at 143 among the 169 countries surveyed for the 2010 Human Development Index [7]. Life expectancy has slowly been increasing to its current level of 53 years, although half of the population are between the ages of 0 and 14 years [5]. The infant mortality rate is 79 per 1,000 live births, compared to a global average of 43 infants per 1,000 live births [4]. More striking is the maternal mortality ratio of 430 deaths per 100,000 live births, compared to a global average of 260 deaths per 100,000 live births. Only 42% of births are attended by skilled health personnel [4, 8].

Uganda is administratively split into four regions (Northern, Eastern, Western, Central), which are further divided into 112 districts (though this number has recently been fluid owing to the election cycle). Health service delivery is achieved through a decentralized system using public and private providers. Its design is derived from the 1999 National Health Policy and the Health Sector Strategic Plan I (2000–2005) and Plan II (2006–2010). The policies are guided by Uganda's Poverty Eradication Action Plan and the Millennium Development Goals.

The design of Uganda's governmental health care delivery system is based on a hierarchy of increasing specialization delivered by public and private providers. The public system is composed of the district health system—Village Health Teams; Health Centers I II, III, IV; general (district) hospitals—regional referral hospitals, and two national referral hospitals. The local district governments manage the district health system, including the general hospitals, and the regional referral hospitals and the national referral hospitals are semiautonomous. The national Ministry of Health is responsible for providing technical supervision, monitoring and evaluation of overall performance, strategic planning, policy to regulate health services, budgeting, and quality assurance. All services provided in governmental facilities, including medicines and equipment, have been free since the abolition of user fees in 2001.

The private providers are composed of private not-for-profit organizations (PNFPs) (75% of which are religion-based), private health practitioners, and traditional and complementary medicine practitioners. The private provider delivery system is largely based on the governmental delivery system described above. Approximately 20% of PNFP facilities are subsidized by the government [6].

There are 128 hospitals in Uganda, which is where most surgical services are provided. The hospitals are divided into 113 general hospitals (public, PNFPs, private), 13 regional referral hospitals (public), and 2 national referral hospitals (public, with one serving solely as a mental health hospital) [9]. Of the 113 general hospitals, 38 are public government hospitals, 51 are PNFP hospitals, 51 are private hospitals, and 9 are institutional hospitals [9]. According to the Ministry of Health's 2006 National Hospital Policy, a health facility is designated a hospital if it provides "curative, preventive, promotive, and rehabilitative care … it should have at least 60 beds, a high level of skilled medical personnel including doctors, and be able to carry out major surgery and advanced investigative procedure.… It should serve a population of at least 200,000 people" [10].

In regard to surgical capacity, the Ministry of Health, through its Health Management Information Systems Division (HMIS), collects annual data regarding numbers of major surgeries, minor surgeries, cesarean sections, trained health workers on staff, and blood transfusions.

This study was carried out to obtain more detailed information on the unknown surgical and anesthesia capacities of the public government hospitals throughout the country, the first point of access for surgery for most of the population. The data can be used to advise the national government on future policy recommendations and service delivery planning. It can also inform the international community about the critical importance of the access to surgery and anesthesia for populations in low-income countries.

Methods

A survey instrument was designed to assess the surgical and anesthesia infrastructure of government hospitals in

Uganda. It was modeled on the World Health Organization tool for situational analysis to assess emergency and essential surgical care (http://www.who.int/surgery/publications/QuickSitAnalysisEESCsurvey/pdf). Eight areas of surgical and anesthesia capacity were examined in detail, including access to hospitals, human resources, infrastructure, surgical case load and diversity, surgery- and anesthesia-related outcomes, essential equipment, pharmaceuticals, and nongovernmental organization delivery of surgical services.

Ugandan health indicators and national health systems statistics can be found in the recent literature for an overview of the state of health resources in the country. In our study, general information about Uganda's health care system, health care provider educational structure, and hospital indicators was collected from the Ministry of Health headquarters in Kampala through the HMIS and interviews with Ministry of Health officials. Information about national drug registration and quality assurance was collected from the National Drug Authority headquarters in Kampala.

A total of 15 hospitals were visited during a 2-week period (Fig. 1). Among them, one was a PNFP mission hospital, two were public government regional referral hospitals, and the rest were public government general (district) hospitals. These hospitals were selected through convenience sampling of hospitals from the four administrative regions in Uganda (Central, East, Western, North). Hospitals were selected if they were reachable by a road recognized by the Uganda National Roads Authority. The mission hospital was used for a comparison to the public government hospital facilities, and its data are not included in the final analysis of the results.

The survey was administered through site visits by two of the authors (A.L., S.S.) and face-to-face interviews with hospital directors, nursing officers, operating theater assistants, and laboratory technicians.

No patient-specific data were collected at any of the facilities visited. Ethical exemption was obtained from Harvard University, Boston, MA, USA, and Makerere University, Kampala, Uganda. The Uganda National Council for Science and Technology approved the study.

Results

Access and availability of facilities

The 14 public government hospitals surveyed served an estimated catchment population of 7,482,600 people, which is approximately 23% of the total population of Uganda. The hospitals surveyed represent 27% of the public government hospitals throughout the country. The mean population served per hospital was 534,471 people (defined as the total population living in the district served by the facility). As estimated by hospital directors, patients had to travel a mean distance of 33 km to reach each hospital. The estimated mean distance to the nearest referral hospital was 68 km (using roads recognized by the Uganda National Roads Authority) (Table 1).

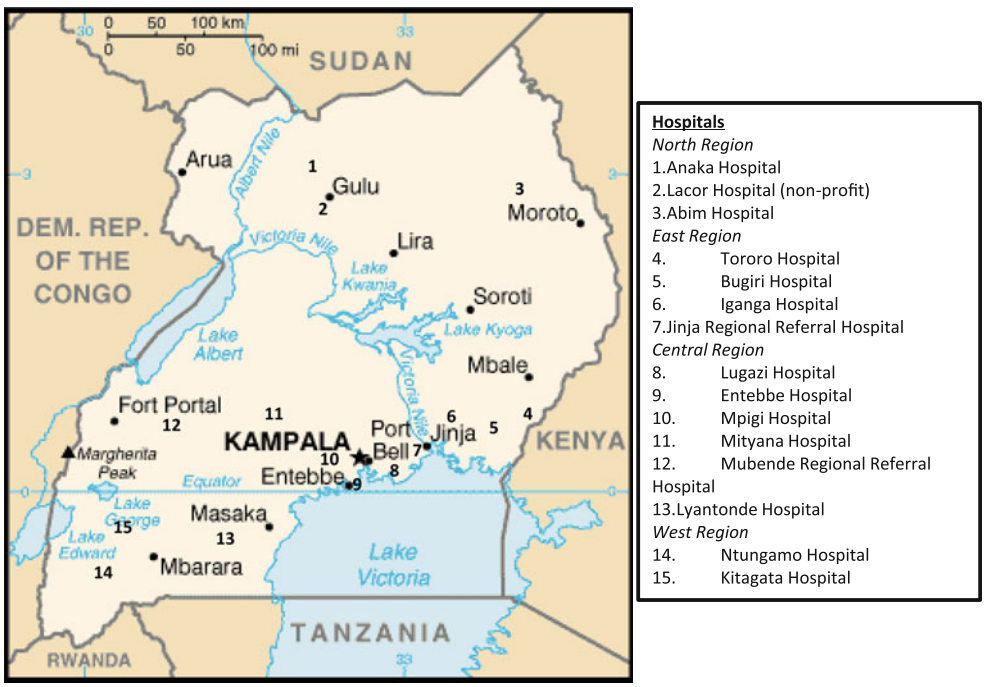

Fig. 1 Hospitals visited

Table 1 Access to surveyed hospitals (by region)

Parameter	North	East	Central	West
Population served	275,600	2,247,600	3,642,800	1,316,600
No. of hospitals	2 (all district hospitals)	4 (2 regional referral hospitals, 2 district hospitals)	6 (all district hospitals)	2 (all district hospitals)
Distance traveled to reach hospital (km)[a]	20	53.75	22.5	35
Distance to nearest referral hospital (km)[a]	92.5	56.5	58.8	85
No. of beds per hospital[a]	102	217	108	100
Inpatient admissions/year[a]	4,255	17,846	9,526	10,732
No. of aseptic operating theaters[a]	0.5	1	1	1

[a] Results are mean numbers unless otherwise stated

Access to human resources

There are 1,570 registered physicians in Uganda [11]. This is a rate of four to five physicians per 100,000 people. In all, 50% of Uganda's physicians work in government facilities, and 23% work in PNFP facilities [11]. Of all registered physicians, 328 are formally trained surgeons, including general surgeons, cardiovascular surgeons, otolaryngologists, neurosurgeons, ophthalmologists, orthopedic surgeons, plastic surgeons, urologists, and obstetricians/gynecologists (OB/GYNs) [Katumba Ssentongo, Uganda Medical and Dental Practitioners Council, Ministry of Health, personal communication]. There are 107 general surgeons, 97 subspecialty surgeons, and 124 OB/GYNs [K. Ssentongo, personal communication]. This is a rate of one surgeon per 100,000 people. A total of 17 anesthesiologists are credentialed for the whole country [K. Ssentongo, personal communication]. As of June 2010, only 41% of all physician positions available at the district level were filled [11].

Among the hospitals sampled, there was one physician per 149,652 people (or 0.67 physicians per 100,000 people) and one surgeon (defined as a formally trained general surgeon, subspecialty surgeon, or OB/GYN) per approximately one million people. Among the 14 public hospitals surveyed, there was a mean of 3.5 physicians per hospital, and only five facilities had a surgeon. Of the nine total surgeons found at these five facilities, six were trained as OB/GYNs, and three were trained as general surgeons.

There are five medical schools in Uganda; four are government-run (Makerere, Mbarara, Gulu, Busitema), and one is private (Kampala International) [11]. Following completion of secondary school, one can attend medical school, which is a 5-year curriculum, culminating in written, clinical, and oral examinations. The next step is a mandatory intern year comprised of rotations throughout several medical specialties. Postgraduate training in surgery consists of 3 years of further specialization training. Only three institutions offer postgraduate surgical training (Mulago Hospital, Mbarara Hospital, Uganda Martyrs University). All physicians must renew their license yearly and must have completed 15 credits of continuing medical education to renew.

Clinical officers, a cadre of mid-level health care providers, between nurses and physicians, help fill the void in the physician workforce. There are 2,603 clinical officers in Uganda, with 2,014 working in public government facilities [11]. A clinical officer degree is offered at four programs (three government, one private) and consists of 3 years of training following completion of secondary school. It can be followed by an additional year of specialized training (e.g., in anesthesia, ophthalmology, orthopedics, dentistry). In regard to surgery, there is one specialized clinical officer training program each in anesthesia, ophthalmology, ear/nose/throat, and orthopedics [11].

A mean of nine clinical officers per hospital (range 1–36) were found among the 14 surveyed hospitals. There was a mean of three surgically specialized clinical officers per hospital, one of these on average being an anesthesia clinical officer.

Anesthesia assistants comprise another task-shifting cadre developed to help fill the void in anesthesiologists. Training consists of an 18-month program following completion of secondary school.

There were no anesthesiologists found at any of the hospitals surveyed. There was a mean of two mid-level anesthesia providers per hospital (either an anesthesia clinical officer or anesthesia assistant). Two surveyed hospitals lacked even one mid-level anesthesia provider. Another two of the surveyed hospitals had only one anesthesia assistant each to deliver all anesthesia needs. It was reported that anesthesia was occasionally or solely administered by the surgeon performing the surgery or an uncertified nurse/theater assistant.

There are a total of 11,053 nurses of all levels in Uganda (excluding midwives and nursing assistants) [11]. More than half of them work at public government institutions [11]. Multiple cadres of nurses exist, from senior to junior levels: degree nurses, registered comprehensive nurses, public health nurses, registered nurses, enrolled comprehensive nurses, enrolled nurses. There are 27 facilities/institutions where at least one of these degrees can be earned.

There are 5,107 midwives, with almost 70% of them working at public government institutions [11]. Similar to nurses, there is a registered midwife and enrolled midwife cadre. There are 14 facilities/institutions where at least one of these degrees can be earned. There are 6,719 nursing assistants in Uganda, with most of them working in public government facilities [11]. Nursing assistant training is completed only on the wards. There are no formal education programs for this cadre.

There was a mean of 41 nurses (range 9–66), 23 midwives (range 6–53), and 34 nursing assistants (range 8–127) per hospital surveyed. Accounting for physicians, clinical officers, nurses, midwives, and nursing assistants, there was one health care provider for every 2,766 people in Uganda (excluding private facility-only providers) or 0.4 health care worker per 1,000 people. In regard to the catchment population surveyed, there was only 0.2 health care worker per 1,000 persons. Among all surgical providers (including surgeons and surgical clinical officers), there was 0.006 provider per 1,000 persons in the surveyed catchment population.

Of the total health workforce available to Uganda (including physicians, clinical officers, nurses, midwives, nursing assistants), 5.8% were physicians, 9.6% were clinical officers, 40.9% were nurses, 18.9% were midwives, and 24.8% were nursing assistants. These proportions were relatively similar when calculated for the surveyed hospitals: 3.2% were physicians; 7.8% were clinical officers; 37.4% were nurses; 20.7% were midwives; and 30.8% were nursing assistants.

There were 288 registered pharmacists in Uganda [11]. There are two pharmacist training programs and one pharmacy technical training program. Only 13% of available pharmacist positions at the district level are filled [11]. Each hospital surveyed had, on average, two pharmacy workers (pharmacist, pharmacy technician, dispenser, pharmacy assistant) (Table 2).

Infrastructure and equipment

Each surveyed hospital had a mean of 11,322 inpatients per government fiscal year 2009/2010. The mean number of beds per district hospital was 115. Almost all hospitals reported that capacity was often 1.5 to 2.0 times their official number of beds, indicating that inpatients were often two to a bed or on the floor. All hospitals except one had a major aseptic operating theater with an additional one or two septic minor operating theaters or procedure rooms. This averaged 0.2 major operating theater per 100,000 people and 0.07 major operating theater per 100 hospitals beds.

The availability of water, electricity, sterilization equipment, waste disposal, oxygen, pulse oximetry and blood bank facilities was examined. In all, 11 of 14 hospitals reported access to piped water, although it was not always reliably available. Three of these hospitals had no backup supply if piped water was not available. The three hospitals that did not have access to piped water had water supplied from a well.

Altogether, 12 of 14 hospitals had electricity supplied from a national grid. All of these hospitals reported frequent power outages. All hospitals had access to at least one generator as either a primary or backup electricity source. Generators were generally used only to power the operating theaters when needed and occasionally the maternity wards and radiography equipment. Use of the generators was limited by the high expense of diesel to power them. Half of the hospitals had solar panels that supplied supplemental energy to power computers and refrigerators.

In regard to sterilization, all hospitals had at least one working autoclave. All hospitals performed surface disinfection of operating theaters after procedures.

Table 2 Human resources at surveyed hospitals (by region) and national cumulative numbers

Human resource	North	East	Central	West	National
Physicians	2	18	23	7	1,570
Surgeons, anesthesiologists, OB/GYNs	0	5	3	1	345
Clinical officers	14	56	35	14	2,603
Nurses	45	291	99	34	11,053
Midwives	22	128	135	31	5,107
Nursing assistants	45	291	99	34	6,719
Pharmacy workers[a]	2	9	11	5	288 (pharmacists only)

OB/GYNs obstetrician/gynecologists

[a] Includes pharmacists, pharmacy technicians, dispensers, pharmacy assistants

In all, 10 of 14 hospitals had waste disposal facilities consisting of both a placenta pit (for human tissue waste) and an incinerator pit (for sharps and all other medical waste). Only four hospitals had a proper incinerator, although use was limited by electricity or generator diesel availability.

Only 8 of 14 district hospitals had access to oxygen, which in each case was in the form of an electric oxygen concentrator. In most cases, the concentrator was not dedicated to the operating theater but was shared by all wards in the hospital. A pulse oximeter was not available at any of the 14 pubic hospitals surveyed.

There are six regional blood banks in Uganda that supply all of the blood to district hospitals within their respective regions. In regard to hospital blood bank capacity, 12 of the 14 hospitals stored a minimal amount of blood in their facility. Among them, seven reported that there were often shortages of blood products available. When blood was needed but unavailable at a hospital, it would be obtained from a nearby hospital or from the closest regional blood bank, if available. Many hospitals reported blood product delivery via public transportation (through handheld coolers transported on local minibuses) or via patient's families traveling to the nearest facility with available blood and transporting the blood back themselves. There was an average of 1,108 units of blood products used per hospital per year, with a mean of one unit per 10 inpatient admissions.

Pharmaceuticals

The National Medical Stores (NMS) is the government agency charged with procuring, storing, and distributing essential medicines and supplies to the public health care sector. The Ministry of Health publishes the essential medicines list for Uganda (EMLU) and the Ugandan National Formulary (UNF). The EMLU, based on the World Health Organization (WHO) essential medicines list, was first produced in 1991, and the latest version is from 2007. Government hospitals use the EMLU and UNF to base their drug requisitions to the NMS. No hospital surveyed had its own customized formulary.

All 14 hospitals reported access to drugs on the EMLU. Equally, all 14 hospitals reported a routine shortage of many of these essential medicines each month. Four hospitals reported often (every 1–2 months) having shortages of antibiotics, seven reported having shortages sometimes (every 3–4 months), and three of them always (monthly) had shortages of antibiotics. Three hospitals reported always having narcotics in stock, whereas six hospitals declared that they never had them. Two hospitals reported that they often had narcotic shortages. Eight hospitals reported often having shortages of nonnarcotic analgesics, two sometimes had shortages, and four hospitals never had shortages.

Procedures

Among the 14 hospitals surveyed, a total of 63,826 surgical cases were performed during the 2009–2010 year. This was a mean of 4,559 cases per hospital and almost one surgery for every two inpatient admissions (1,442 cases per hospital and one surgery for every 10 inpatient admission when excluding tooth extractions).

Of the 13 hospitals with the capability to perform a major surgery, 11,514 were completed, constituting 18% of all surgical cases (or 57% of all cases when tooth extractions were not included). Minor surgeries comprised 82% of all cases (or 43% of all cases when tooth extractions were not included).

A total of 154 major surgical procedures were done per 100,000 people. One surgical procedure (major or minor) was done for every 117 people. OB/GYN cases (cesarean sections and evacuations) constituted 14% of all cases done; the number increased to 44% of all cases done when extractions were excluded. This was roughly 77% of all major procedures performed, with cesarean sections alone comprising 54% of all major procedures. For the 13 hospitals with the capacity to perform a cesarean section, each hospital did 478 per year on average.

Excluding tooth extractions, 53% of all cases were general surgery cases (laparotomy, tracheostomy, thoracotomy, other major procedures, hernias, débridement/skin grafting, incision and drainage, other minor procedures). Of all major procedures, 22% were general surgery cases. Excluding extractions, 94% of all minor procedures were general surgery cases. On average, each hospital performed 764 general surgery cases. Excluding tooth extractions, 73% of all cases were done on an emergency basis (defined as all major surgeries plus débridements and incision and drainage).

Of all surgical procedures, tooth extractions were the most numerous (43,637) followed by cesarean sections (6,213). These were followed by "other minor procedures" (2,998), evacuations (2,667), and hernias (1,914). Excluding tooth extractions, operations per 100,000 people ranged from 21 to 1,514 per hospital (Table 3).

Outcomes

Each hospital had a theater logbook recording all procedures done. Data collection was fairly uniform and included the name, age, and sex of the patient; diagnosis; procedure; name of the surgical provider; and occasionally "remarks" about the surgery. "Remarks" were a measure

Table 3 Procedures at surveyed hospitals (by region)

Procedure	North	East	Central	West
Major surgery (no.)	77	5,225	4,997	1,215
Cesarean section	46	2,339	2,988	840
Evacuation	0	1,335	1,086	246
Laparotomy	3	893	416	101
Internal fixation	0	69	1	0
Burr hole	0	0	0	0
Tracheostomy	0	11	0	0
Thoracotomy	0	51	0	0
Others	28	524	509	28
Minor surgery (no.)	292	25,710	24,150	2,160
Tooth extraction	30	21,198	20,750	1,659
Hernia	0	991	655	268
Incision and drainage	88	775	727	80
Débridement/skin graft	81	1,102	360	20
Plastic surgery	0	40	4	0
Ocular surgery	0	172	1	0
ENT surgery	0	232	91	0
Others	93	1,302	1,460	133
General surgery procedures (no.)[a]	293	5,649	4,127	630
OB/GYN procedures (no.)[b]	46	3,677	4,071	1,086
Emergency procedures (no.)[c]	246	7,102	6,084	1,315

ENT ear/nose/throat

[a] Includes laparotomy, tracheostomy, thoracotomy, other major procedures; hernias, incision and drainage, débridement/skin grafting, other minor procedures

[b] Includes cesarean section, evacuation

[c] Includes cesarean section, evacuation, laparotomy, internal fixation, burr hole, tracheostomy, thoracotomy, other major procedures; incision and drainage; débridement/skin grafting

of outcome by the surgeons. Only eight hospitals recorded a remark/outcome, using simply "good," "ideal," or "repaired." Many other hospitals recorded outcomes as a simple check mark, indicating completion. Only two hospitals recorded intraoperative deaths in the logbook, although there was no reference made to the cause of death. Only five hospitals had any kind of mortality review if a surgery- or anesthesia-related death occurred, although it was informal and irregular except for one hospital that had a formal morbidity and mortality committee.

Of the 14 hospitals surveyed, 12 reported having formal maternal audit teams that tracked obstetric deaths. Four hospitals reported having regular maternal audit meetings to review maternal mortalities.

Neither surgical complications nor adverse drug reactions were recorded at any hospital. The National Pharmacovigilance Center, a division of the National Drug Authority, does track adverse drug reactions through an individual-incident voluntary reporting form.

Discussion

There are many challenges when providing comprehensive, safe surgical care to a population in a low-income country, especially as provided by public government hospitals. In all, 41% of hospitals in Uganda are government operated and managed. This study sought to categorize the surgical capacity of public government hospitals in the hope that the results will encourage strengthening the existing health infrastructure at those facilities that should potentially be free of charge and accessed by the poorest populations. (There is currently no national health insurance scheme in Uganda.)

Distance to health facilities has been shown to be a major barrier to accessing health services [12]. In regard to surgical care, timely access is important because of the urgent nature of many surgical conditions. This study revealed an estimated mean 30 km traveled by each patient to reach a facility providing surgical care, which translates into a direct barrier to preventing surgical morbidity and mortality. With almost 75% of the procedures considered an emergency, the extent of people who could not reach a facility in time is potentially substantial, although the true unmet need for surgical care in the community is unknown.

Examining access to surgery by region, those located in the eastern region appear to have the farthest to travel to reach a government hospital. This figure is likely skewed, though, because of the region's proximity to the Kenyan border (many hospital directors reported patients arriving from Kenya). This could also be the case with the western region with patients from Rwanda and the Democratic Republic of Congo seeking care. The north region revealed the greatest distances to travel to a referral hospital, likely due to the region's protracted guerilla war and resulting paucity of health infrastructure development.

The scarcity of the surgical workforce in sub-Saharan Africa has been well documented in recent literature [13, 14]. To further elucidate the global disparity, the finding of one physician per 20,834 Ugandans can be juxtaposed against the one physician per 460 U.S. population [15]. When examining Ugandan national data, the finding of four to five physicians per 100,000 people agrees with previous national estimates [13]. It must be examined, though, why this finding has not changed during the last 5 years (when previous data were collected) despite the large population growth.

When examining the surveyed population, there was only 0.67 physician per 100,000 people. This disparity could be due to the distribution of physicians in Uganda. It has been found that more than 90% of physicians are located in Kampala, whereas the hospitals surveyed ranged from 30 to 500 km from Kampala [6]. In a country where 85% of the population lives in rural areas, this disparity in

physician distribution proves a great challenge to providing surgical care [6].

Uganda has a unique cadre of mid-level practitioners, or clinical officers, which has allowed task-shifting of surgical services. There were four surgical clinical officers for every one surgeon, and 1,451 (459 excluding tooth extractions) surgical procedures were performed per surgical provider (surgeon or surgical clinical officer). Thus, a substantial proportion of procedures will potentially be done by this mid-level cadre. Although every hospital had from one to eight general medical physicians, only two hospitals had formally trained general surgeons, which brings to question the educational guidance available to these surgical clinical officers and the potentially dangerous lack of assistance when a serious complication arises.

Anesthesia is another vital component for providing safe surgery [16, 17]. There were no anesthesiologists at any of the surveyed hospitals and only 0.3 nonphysician anesthesia provider (anesthetic clinical officer or anesthetic assistant) per 100,000 people. This is fewer than previous national studies have found (0.9–1.1 physician and nonphysician anesthesia providers per 100,000 people) [18]. Physicians often reported providing anesthesia themselves or by instruction through a nurse, further illustrating the lack of anesthesia providers.

The finding of 0.4 health care worker per 1,000 people places Uganda among the 57 countries with critical shortages in their health workforces—below which high coverage of essential interventions is unlikely [19]. Per WHO standards, a country with fewer than 2.28 health workers (physicians, nurses, midwives only) per 1,000 persons is considered as having a severe shortage of health workers to meet its health needs [19].

Excluding the two regional referral hospitals, the average number of beds per hospital was 115. This is a number that has remained relatively constant despite the 3.2% population growth of the country [20]. One surgical procedure (excluding tooth extractions) was performed for every 10 inpatient admissions. Although it was unknown how many outpatient versus inpatient procedures were done, the maximum potential that 10% of inpatient admissions are for surgery indicates that infrastructure to support this patient population is essential.

There was 0.2 major operating theater per 100,000 people, which is below the estimated Eastern Africa regional average of 1.1 major theatres per 100,000 people [21]. This places the study catchment population among the two billion who do not have adequate access to surgical care [21]. Despite this fact, 853 procedures were performed per 100,000 people (270 procedures excluding tooth extractions), which means an average of 1,877 procedures per operating theater (1,553 excluding tooth extractions). Compared to previous estimates, the rate of cases per 100,000 people is equivalent, but the rate of cases per theater is much higher [18, 20, 21]. This further illustrates that resources do not match the need. Combined with an unreliable supply of continuous water and electricity, these essential components of providing surgical care only reinforce the inadequate access to surgical services.

One surgical procedure (excluding tooth extractions) was done for every 371 people in the catchment population. Previous estimates show that about one major procedure for every 25 people is done when using the global volume of major surgery uniformly distributed among the global population [3]. This confirms the lower rate of surgical procedures being done in low-income versus higher-income countries. The poorest one-third of the world's population, of which Uganda falls within, undergo just 3.5% of all operations done worldwide [3]. This same population also has the highest burden of surgically treatable disease [2]. When examined regionally, one procedure was done for every 812 people in the north while one procedure was done for every 231 people in the east (excluding tooth extractions). This reveals even further disparities in access to surgery in Uganda.

Importantly, almost 75% of all procedures done were emergencies. Per the WHO and recent expert opinions on essential and emergency surgical and anesthesia standards, there should be a reserve of blood, an oxygen source, a pulse oximeter, and essential medications available at every facility performing surgery [22, 23]. No hospital surveyed had a continuous supply of these essentials, and none had a usable pulse oximeter. This only reinforces the burden of morbidity and mortality that could be averted with proper, safe surgical care. Reinforcing the consequences of inadequate surgical infrastructure is the dire finding of a facility-based maternal mortality rate of 671 per 100,000 live births [24].

Almost half of all procedures done (excluding tooth extractions) were general surgery cases, and approximately 45% were obstetric cases. This proportion matches estimates found in a recent study examining hospitals in Mozambique, Tanzania, and Uganda [20]. Tooth extractions accounted for the greatest proportion of the procedures, highlighting the urgent need for more advanced dental care.

Cesarean sections comprised the next largest proportion of procedures—8.3 per 10,000 people—which is on par with previous estimates [20]. Also, 42% of all emergency procedures were cesarean sections. The population need for cesarean section is estimated to be 5–15% of all deliveries [25]. Using the conservative end (5%) and a birth rate of 46 per 1,000 population, the annual need for cesarean section for the catchment population is 17,210 [4]. The unmet need for cesarean section equates to a substantial 64%. Accordingly, only 40% of designated facilities in Uganda

are able to provide appropriate emergency and obstetric surgical care [7]. This illustrates the impact that appropriate surgical services could have on achieving millennium development goal 5 (reducing maternal mortality).

The general lack of explicit information recorded in the surveyed hospitals in regard to outcomes and perioperative complications and deaths is important. Studies suggest a complication rate of 5–20% for major surgery in developing countries, with anesthesia mortality rates up to 1 in 340 [26, 27]. Without reliable indicators for these outcomes, though, it is difficult to investigate where improvements can be made. It is promising that most of the hospitals in our study had a maternal audit team to record the number and causes of maternal deaths. More standardized meetings are needed to discuss the causes of death, and process improvements need to be encouraged.

There are many limitations to this study. Most of the individual hospital data were obtained via direct interviews. Some of the information was double-referenced with information collected at NMIS (e.g., human resources, types of surgical procedure), but estimates were often different at the two levels. This places inherent limits on all estimates because of recall bias of the interviewed participants. The hospitals included in this study are all public government-funded hospitals. Thus, study estimates of the unmet need for cesarean section are probably higher and study rates of procedures per population and human resources per population are likely lower than in actuality. When categorizing types of procedures, designation of "major" and "minor" procedures was used to conform with Ugandan reporting standards. A high percentage of procedures were reported as "other major procedures" or "other minor procedures." This ambiguity could have affected how general surgery procedures, obstetric procedures, emergency procedures, and types of procedure done were calculated. The convenience sampling method used to choose the surveyed hospitals results in nonrandomized data. There were some large regions of the country that were not sampled, most notably the northeastern and northwestern areas of the country, which have traditionally been underserved. Regional comparisons of human resources, infrastructure, and procedures, although informative for planning, likely do not adequately represent what exists.

Conclusions

The surgical capacity of Uganda's public hospitals falls below many international standards. The volume of surgery being done is impressive, though, given the lack of adequate infrastructure, supplies, and human resources. Investing in surgical services in a low-income country setting not only promises to prevent premature disability and death, it is also cost-effective. Combined with studies on surgical capacity such as this one, these data provide ample evidence for an area of health care that is not being adequately addressed by national governments or international organizations.

Acknowledgments We thank all of the Ugandan Ministry of Health officials, hospital directors, clinical officers, nurses, operating theater assistants, and laboratory technicians without whose help and enthusiasm this study would not have been possible.

Conflict of interest The authors declare that there was no grant support or conflicts of interest.

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