ABSTRACT

Somaliland Surgical Capacity:
The Effect of Surgical Capacity on Elective and Emergent Pediatric Surgical Care

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Pediatric surgical service is severely lacking in Low to Middle Income Countries (LMICs). Specifically, in the country of Somaliland children are at greater risk for disability and death due to poor surgical capacity. This study aims to identify current surgical capacity and the specific items to increase to improve pediatric surgical care. A survey was conducted to identify the surgical capacity of hospitals (n=15) and pediatric surgeries (n=1,255) completed between August 2016 and July 2017. The data were analyzed through SAS to retrieve results. Only 5 out of the 15 hospitals had the minimal surgical capacity to serve the population. Of the 1,255 pediatric surgeries, 712 were elective and 505 were emergent surgeries. The evidence suggested that surgical capacity could improve by increasing infrastructure, personnel, and surgical delivery. Investing in surgical capacity could increase the surgical care for children in Somaliland.

Somaliland Surgical Capacity:
The Effect of Surgical Capacity on Elective and Emergent Pediatric Surgical Care

by

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A Thesis

Accepted by the Department of Public Health

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Eva Doyle, Ph.D., Chairperson

Submitted to the Graduate Faculty of
Baylor University in Partial Fulfillment of the
Requirements for the Degree
of
Master of Public Health

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May 2020

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LIST OF ABBREVIATIONS

AH	Alaale Hospital
AHH	Al Hayat Hospital
BeRH	Berbera Regional Hospital
BoRH	Boroma Regional Hospital
BuRH	Burao Regional Hospital
CI	Confidence Interval
CME	Continuing Medical Education
CT	Computed Tomography
DALYs	Disability Adjusted Life Years
DXH	Daarul Xanan Hospital
EAUH	Edna Adan University hospital
GDP	Gross Domestic Product
GICS	Global Initiative for Children's Surgery
GMH	Gargaar Multispecialty Hospital
GRH	Gabiley Regional Hospital
HGH	Hargeisa Group Hospital
HICs	High Income Countries
HNH	Hargeisa Neurology Hospital
LCoGS	Lancet Commission on Global Surgery 2030
LMICs	Low to Middle Income Countries
MASCTH	Mohamed Aden Sheikh Children's Teaching Hospital

MSH	Manhal Specialty Hospital
NGO	Non-Governmental Organization
NICU	Neonatal Intensive Care Unit
OR	Odds Ratio
PCA	Principal Component Analysis
PediPIPES	Pediatric Personnel, Infrastructure, Procedures, Equipment and Supplies tool
PIPES	Personnel, Infrastructure, Procedures, Equipment and Supplies tool
PLUS	Duke Global Health Placement of Life-changing Usable Surplus program
SAS	SAS version 9.4 (English) software
SAT	WHO Emergency and Essential Surgical Care Situational Analysis Tool
SDH	Sheikh District Hospital
SHCA	Somaliland Hospital Capacity Assessment
SOA	Surgeon, Obstetrician, and Anesthesiologist
SPSRRT	Somaliland Pediatric Surgical Record Review tool
SSSL	Safe Surgery Saves Lives programme
TASSEESCO	Situational Analysis to Assess Emergency and Essential Surgical Care
WFSA	World Federation of Societies of Anesthesiologists
WHO	World Health Organization

ACKNOWLEDGMENTS

I would first like to thank Dr. Emily Smith of the Public Health Department at Baylor University. She was always there to provide support and encouragement during the rough days when the data became complicated and overwhelming. She also advised me that failure was inevitable but a necessary step to success.

I would also like to thank Dr. Smith's research team and Tessa Concepcion M.S. for collecting the data and providing help from across the U.S when requested.

I would like to acknowledge my committee members: Dr. Asare of the Public Health department and Dr. Pitts of the Biology department at Baylor University. They provided support during the hectic days of thesis writing.

Finally, I would like to thank my parents for providing encouragement and support during my years in school. This project would not have been completed without their continued prayers and words of encouragement. Thank you.

DEDICATION

To my parents, for all the support.

To my grandparents, for all the prayers.

To my siblings, for all the laughs.

To my family and friends, for everything else.

CHAPTER ONE

Introduction

Surgical care is receiving greater attention in the global arena due to the increasing surgical needs in Low to Middle Income Countries (LMICs). The Lancet Commission on Global Surgery 2030 (LCoGS) emphasizes the necessity and benefit of increasing surgical care in LMICs.[1] Currently, countries are becoming more aware of their surgical need and are beginning to allocate more resources to the hospitals to improve surgical care and outcomes. However, countries that are categorized as LMICS are indicating a high surgical demand but the population is not receiving it due to the low surgical capacity of the hospitals.

The LCoGS stated that investing in surgical care could aid LMICs in preventing at least 77.2 million Disability Adjusted Life Years (DALYs).[1] LMICs that invest in surgical capacity can improve their surgical outcomes. There are specific surgeries that countries must be capable of completing according to the LCoGS indicators to be surgically sustainable. Those surgeries are known as the bellwether procedures which include laparotomies, cesarean sections, and setting fractures.[2] However, for these surgeries to be accomplished, hospitals must have the proper surgical capacity.[1] Many LMICs do not have the capacity needed to properly serve their population.[1] There are ten needs the LCoGS stated for a country's surgical facilities to be fully functional. These ten needs focus on infrastructure, number of surgical providers, and access to testing equipment and medications.[1] Overall, the LMICs have not been able to reach the desired threshold. The LCoGS reported that many hospitals and surgical facilities exceed their

capacity greatly.[1] Tertiary hospitals exceed their surgical capacity by 200-300%[1] which demonstrates the necessity of surgical care for patients in many countries that have low surgical capacity.

The surgical capacity of a hospital must meet the needs of the surrounding population to be fully operational. The country of Somaliland is severely lacking in the realm of surgical care for their population. Somaliland has the fourth lowest gross domestic product (GDP) in the world[3] which causes surgical care to be a low priority.[1]

In 1991, Somaliland had declared independence from Somalia which ended a brutal civil war.[4] Currently, the country is working to rebuild health services for their population and surgical services are beginning to emerge on the list of importance.[4] Somaliland has high rates of infant and maternal mortality and is 161 out of 163 of the least developed countries in the world.[4] The Somaliland government is making great strides to improve the health services of the country and reverse the mortality rates in the country.[4] However, the biggest hurdle the country is facing is the lack of surgical providers and trainers.[4] Edna Adan a former foreign minister of Somaliland said, [4] There is a recognized need for increasing surgical capacity to provide improved services to the population of Somaliland.

In addition to increasing surgical capacity, it is crucial that the population most at risk is targeted. Children are at the greatest risk in LMICs with low surgical capacity. They account for 50% of the population in LMICS and 92% of congenital conditions occur in LMICs. [5] The children with untreated congenital conditions have a mortality rate of 17-43%.[5] The economic and political future of countries rely on their child population reaching adulthood. If the children do not receive the necessary surgery, they will either

die or live with a life-long disability increasing the burden on the country. Specifically in Somaliland, the prevalence of pediatric surgical conditions is 12.2% and 76.3% of those conditions are untreated.[6] However, the hospitals do not have the surgical capacity to meet that need. Surgical care becomes a low priority in Somaliland due to the lack of funds and resources to sustain minimal surgical capacity.

However, if the government of Somaliland prioritizes investing in surgical capacity, survival rates will increase and economic growth will be achieved. The infrastructure of the surgical care system must be developed further in Somaliland to improve the health of both the child and adult population.[1] Pediatric surgery whether elective or emergent is contingent upon the surgical capacity of a hospital.

Investing in Global Surgery

There are organizations and governments that are hesitant to invest in global surgery because it requires resources from their already limited supply and is perceived to be too expensive for LMICs. However, previous research has demonstrated that investing in global surgery is better financially for the country and more sustainable than if individuals needing surgery do not receive the surgical care.

A study by Chao et al[7] assessed the cost-effectiveness of surgery by examining the surgical procedures completed by the hospitals and the surgical facilities' resources. Chao et al[7] stated, "While the perception of surgery as an expensive intervention has been a barrier to its widespread acceptance in global health in the past, available data indicate that investment in surgical care delivery is worthwhile from an economic perspective." Surgeries that were thought of as too expensive for LMICs are now becoming possible and even financially attainable due to the efforts of the global surgical community.

Providing surgical care can decrease the high mortality rates afflicting the LMICs. There are specific surgical procedures that LMICs should invest in to improve their surgical service and outcomes. Mock et al[8] categorized surgeries into three groups to easily determine which procedures should be the main focus in LMICs with low resources. Priority one includes surgical airway, cesarean section, and appendectomy which hospitals should have the ability to complete before dealing with priority two or three surgeries.[8] It is important to note that different LMICs might have different surgical priorities and should base their services off of the current surgical needs not just the list of surgeries above.[8]

Bellwether Procedures

The LCoGS utilized the bellwether procedures as an indicator of a functioning hospital at the minimal level.[1] The bellwether procedures consist of three surgeries: cesarean section, laparotomy, and fracture setting.[1] The ability of a hospital to properly complete these surgeries, demonstrates it is at a level to complete many other essential surgeries.[1,9]

A study by Haider et al[10] defined the purpose of surgical indicators. They laid out three main goals of an indicator: [10]

> (1) to serve as tools for advocacy, quality, and patient-centered care at the local, national, and international level; (2) to guide decision making around surgical services at the local and national level; and (3) to assist fundraising and resource mobilization efforts by demonstrating existing needs and goal-oriented progress over time.[10]

One study utilized only a cesarean delivery as an indicator for proper surgical service and concluded it was a reliable estimator for surgical care.[11] Another study analyzed hernia repair, a laparoscopic surgery, as their indicator of quality surgical service.[12] They

discovered that it was a consistent indicator for surgical capacity.[12] These two studies support the claim of the LCoGS that the bellwether procedures can be utilized as indicators for effective surgical service.

Utilizing the bellwether procedures as a surgical indicator will effectively meet the goals provided by Haider et al[10]. The procedures can serve as a tool to advocate for better patient care at all levels. They are standard procedures that if executed properly demonstrate that the hospital has the ability to complete other necessary procedures. [1,9] The procedures that can be completed outside of the three bellwether procedures include all obstetric and gynecologic, general surgery, emergency, basic, and orthopedic procedures.[2]

Also, the bellwether procedures can be utilized as a guide to improve the surgical services as a hospital. The completion of these procedures demonstrates a functioning surgical care unit at a hospital. However, if they cannot be completed, then surgical capacity must be increased to meet the need of the surrounding population.[2] The procedures also identify equipment or supplies needed for a hospital as well as funding to support surgical initiatives. The hospitals can utilize these procedures to monitor the effectiveness of their surgical care within the community.[2]

The current bellwether procedures are not able to provide information on the capacity of a hospital to perform cleft repair or neonatal surgery which are categorized as pediatric surgery[2] The bellwether procedures are an effective indicator to determine overall surgical capacity for a hospital but do not provide adequate information for pediatric surgical outcomes. Currently, there are no pediatric bellwether procedures to

use as an indicator so the previously mentioned bellwether procedures will be utilized in this study.

Economics

A goal set by the LCoGS is that surgical care must be affordable and not thrust patients into extreme poverty.[1] Out of Pocket cost can be detrimental to the patient receiving care and to their families working to finance their care.[13] Individuals have to pay for medical care as well as transportation, food, and boarding which creates a larger burden on them and their families.[13] All over the world patients are facing catastrophic expenditures due to surgery.[13] In Zambia 56% of patients and in Vietnam 26% of patients that received surgery faced catastrophic expenditures.[13] A catastrophic expenditure is defined as "direct out-of-pocket costs from surgical care >10% of annual income or 40% remaining after subtraction of food and housing accounted for."[13] Surgical costs are continuing to force families to fall below the poverty line.[1]

In LMICs many patients seeking care already fall below the poverty line.[1] If this trend continues where people cannot afford surgery or surgical costs push them into poverty, the country will fall into economic decline due to the lack of individuals contributing to society.[1] The LCoGS stated, "Lower-middle-income countries will have the greatest losses: by 2030, our estimates suggest that surgical conditions in lower-middle-income countries could reduce annual GDP growth by almost 2%."[1] Surgical care and services are crippling not just the individuals but has residual effects on the entire country. The loss of economic welfare due to surgical conditions was estimated to be at least $14.5 trillion.[1]

The pediatric population suffers greatly with the high cost of surgery. The types of surgery that are needed to resolve pediatric conditions can be extremely expensive due to the unique anatomy of children.[14] MacKinnon et al discovered that 45.4% of the pediatric surgical patients surveyed, accrued catastrophic expenses due to surgery.[15] Pediatric surgical patients accumulate higher costs than children only seeking medical attention.[15] The families of these children have to pay the extreme costs which can result in an increase in poverty.

To prevent further loss to the country and patients, investment in surgical care is crucial.[1] LMICs need to invest in surgical scale up and equitable health financing.[1] The cost of scale up for 88 LMICs is $420 billion. Though the cost of investment is high, the cost of inaction is higher.[1] Specifically, a loss of $12.3 trillion to LMICs will result.[1] Investing in surgical care is better financially for a country even if the initial cost is expensive. Investment over time will significantly improve the health of the people which will improve the economy of the country by placing capable individuals back into the workforce.

Workforce

Investing in the workforce is another area that can improve global surgical outcomes. Surgeons are severely lacking in LMICs which means patients are not receiving the necessary surgical care by trained individuals. A study by Rose et al[16] stated that the global per capita surgical need is 4,664 per 100,000 population. They also claimed that 321.5 million surgical procedures are needed to meet the global need.[16] Much of the surgical workforce is concentrated in High Income Countries (HICs). The threshold the LCoGS set for the minimum workforce in a hospital is 228 skilled

professionals per 100,000 population.[1] They have found that 83 countries still fall below this threshold due to misdistribution of the global surgical workforce.[1] It is estimated that only 12% of specialist surgeons work in Africa and South Asia which contain a third of the world's population.[1]

The completion of bellwether procedures requires surgeons with a trained set of skills. The LCoGS recognizes that these surgeons have to specialize in many areas to provide surgery for underserved, rural communities.[1] The extreme conditions of these rural settings where surgeons practice can cause burnout.[1] The LMICs are drained of surgeons due to burnout and lack of adequate resources to provide surgery for the population.[1]

Investing in more workforce or even training can improve the surgical outcomes of LMICs. Due to the time and cost it takes to train a professional surgeon it might not be feasible to acquire every surgeon in this manor but task shifting is a viable option in LMICs.[17]

> Task shifting aims to optimize access to care through reorganizing the workforce. Specifically, it is the process of delegating appropriate health care tasks to a less specialized cadre of workers (including physician and nonphysician providers) to improve access to care.[17]

Task-shifting can increase the number of surgeries completed in LMICs which improves surgical service without incurring high cost due to training new surgeons. Task-sharing is another way to reduce the surgical burden of LMICs. However, some surgical specialists believe it is unsafe to share surgical responsibility with an untrained individual due to the complexity of surgeries.[1] Pediatric surgery is highly specialized due to the nature of the surgery required for children.[14] This might be an area where investing in more training could be beneficial to the outcome.

Equally important to physicians are the teachers and educators that instruct the surgical workforce. It is known that many volunteer surgeons and volunteer organizations work as educators for LMIC surgeons.[1,17] Volunteer organizations were discovered to be effective in training surgeons because of their access to resources and have created successful lessons to make the programs sustainable.[17] An LMIC can invest in bringing a volunteer organization to their country to train their current surgical care professionals to improve surgical outcomes. Investment in pediatric surgery training will be necessary to increase positive outcomes for the pediatric populations.

In conclusion, investing in surgical care is beneficial to both the patient and the country providing the care. The economy will benefit by significantly reducing the loss in GDP if surgical care was not improved. The care of patients would increase and would prevent patients from facing extreme poverty due to high surgical costs. Surgical care is worth investing in to improve the health and financial status of a country.

Goal

Global surgery demands the attention of the world because of its ability to change the health status of developed and developing countries. The Lancet Global Surgery 2030 reported that 9 out of 10 people in LMICs could not receive essential surgical care.[1] The goal of this study is to determine the area at which Somaliland hospitals must increase their surgical capacity to complete the bellwethers procedures (cesarean section, laparotomy, and fracture setting) and establish whether or not it affects the completion of emergent or elective pediatric surgery. This project will utilize previously collected data from Somaliland.

In order to achieve this goal, I propose three aims:

AIM 1: Determine the current surgical capacity in Somaliland for each hospital. Data for the current surgical capacity of Somaliland will be obtained from a previous study which determined the prevalence of pediatric surgical conditions across Somaliland.

AIM 2: Identify the pediatric surgeries completed in each hospital. The pediatric surgical data will be utilized to identify how capacity affects the emergent and elective pediatric surgeries.

AIM 3: Determine what factors of surgical capacity influence completion of emergent or elective surgeries. Surgical capacity includes personnel, infrastructure, procedures, equipment and supplies. Through this study, we will identify which area has the greatest effect on the completion of emergent or elective surgeries.

The need for increased surgical capacity in LMICs is crucial to increasing the overall health of the country. Many countries have poor surgical capacity. This lack of surgical infrastructure can be dangerous due to deficiency of trained providers and surgical equipment which can be detrimental to the population as a whole.[1] I aim to provide a feasible surgical capacity that Somaliland must increase to improve their ability to safely perform surgery.

CHAPTER TWO

Surgical Capacity

Introduction

Investing in surgical care is the next step in changing the global healthcare status of countries. To further the progress of global surgery, it is necessary for Low to Middle Income Countries (LMICs) to determine the areas that require improvement to increase surgical care. The Lancet Commission on Global Surgery 2030 (LCoGS) aims "to improve access to safe, affordable surgical and anesthesia care in LMICs," and provide, "a template for a national surgical plan."[1] It is important to recognize that improvements in hospital systems must be sustainable and affordable for developed and developing countries. Many individuals have identified surgical capacity as the place to scale up hospital systems to improve surgical services. However, surgical capacity does not have an exact definition which can make it difficult to know exactly where a hospital needs to build up resources. The LCoGS identified six core surgical indicators that measure the strength of the surgical system:[1]

> The six core indicators include: "a minimum of 80% coverage of essential surgical and anesthesia services per country by 2030; 100% of countries with at least 20 surgical; anesthetic, and obstetric physicians per 100,000 population by 2030; 80% of countries by 2020 and 100% of countries by 2030 tracking surgical volume; a minimum of 5000 procedures per 100,000 population by 2030; 80% of countries by 2020 and 100% of countries by 2030 tracking perioperative mortality; in 2020, assess global data and set national targets for 2030; 100% protection against impoverishment from out-of-pocket payments for surgical and anesthesia care by 2030; 100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anesthesia care by 2030."[1]

The indicators cover personnel, finances, and surgical operations which all fall under surgical capacity. Previous research has identified key areas that can be utilized to assess the surgical capacity of different hospitals. The purpose of this literature review is to create a working definition for surgical capacity to be utilized later in the study to assess the surgical capacity of Somaliland hospitals.

Methods

A systematic review was conducted using Baylor OneSearch to identify and collect sources related to surgical capacity. Key words used to find these sources were surgical, capacity, and global. The search was further refined by collecting articles between the year 2010 and 2019 and placed into a PRISMA Flowchart (Appendix A).

The total number of results was 82,662. The results were further separated by title. If an article did not have surgical and capacity in the title, then it was discarded. The articles were refined further by reading the abstracts and if an abstract did not contain proper information about surgical capacity, it was rejected. The final number of articles used in the literature review is 25 articles. Each article was read and placed into a table based on the information provided. The definition of surgical capacity from each article was placed into the table to organize them based on key words. The table was used to discover a proper working definition of surgical capacity for a future study.

Results

Surgical capacity does not have a singular definition and is utilized according to the item of interest for the researcher (Appendix B). The definitions cover hospital resources from personnel and training to medical supplies and number of beds. A singular

definition is necessary to identify the area that a hospital should focus to scale up surgical capacity for an increase of surgical service.

Personnel

Personnel was a term identified in the systematic review which covers all people in a hospital system from an anesthesiologist to a medical educator.

Aliu et al[17] claimed that there is a shortage of healthcare workers in LMICs which creates a greater burden on the country leaving more people without surgical care. Increasing surgical care providers is expensive and time consuming. The researchers recommended task-shifting to alleviate some of the burden.[17] Task-shifting is defined as, "the process of delegating appropriate health care tasks to a less specialized cadre of workers (including physician and nonphysician providers) to improve access to care."[17] It concluded that developing task-shifting programs can aid in building surgical capacity which would lead to improvement of the level of surgical service in the country.[17]

A report by Deckelbaum et al[18] highlighted the importance of the surgical workforce and its ability to increase surgical capacity. The number of surgeons to populations in LMICs are very low. Specifically, in sub-Saharan Africa there are only 0.9 physicians per 1000 population.[18] This lack of physicians places a great burden on the current physicians in the region. To improve the level of care, a curriculum was developed to bring physicians to the LMICs as educators for the residing physicians.[18] The goal was not to replace the current physicians but to provide knowledge and skills to where they could better serve their populations.[18] They concluded it provides sustainability to the community because it decreases dependence on outside programs.

Furthermore, it supplies the current surgeons with better practices and increases the support for the physician within the community.[18]

A study conducted by Patterson et al[19] claimed that 6% of the 313 million surgeries that occur each year are performed in LMICs. The need to improve surgical capacity in LMICs is necessary for these countries to perform more life-saving surgeries for their population. Patterson et al[19] focused on Haiti which is the poorest country in the western hemisphere. The surgical workforce is estimated to be 5.9 surgeons per 100,000 people.[19] There are not enough surgeons to adequately serve the population. The hospital of interest was St. Boniface Hospital where the researchers increased surgical capacity by implementing three phases. Phase one consisted of visiting surgical teams performing general surgeries. Phase two was hiring a full-time general surgeon that was on call. Phase three was providing two general surgeons to run a new operating center with three operating rooms. After evaluating the results from phase one to phase two they discovered a threefold increase in surgical volume and a twofold increase in surgical volume between phase two and phase three.[19] The study concluded that there was a positive impact to improving surgical capacity through increasing the surgical workforce.[19]

Petroze et al[20] reported on the surgical initiative of Rwanda. They followed a system-strengthening project which focused on increasing and improving surgeons and surgical care workers to increase surgical capacity.[20] The initiative concluded that providing surgical training programs is important to increasing the number of surgical providers.[20] They also emphasized the need for collaboration between hospitals and healthcare providers to improve surgical outcomes.[20]

The above studies all concluded that it is necessary to increase surgical providers and personnel to strengthen surgical capacity in LMICs.

Infrastructure

Another topic highlighted in the systematic review was infrastructure. Many studies identified the components of infrastructure as important because they affect the surgical outcomes of populations.

A study by Albutt et al[9] conducted an evaluation of surgical capacity in Uganda and the six core surgical indicators provided by LCoGS. The study focused on the country of Uganda which is among the poorest countries in the world based off their Gross Domestic Product (GDP) of $676 on average. The country contains 59 government hospitals which fall under the public sector of healthcare. There are approximately 3,680,000 Ugandans that need surgery and 1,380,000 that require surgical treatment. The researchers conducted a surgical capacity assessment of the country to determine the baseline of the surgical indicators. The researchers defined infrastructure as electricity, oxygen, and running water. They discovered that when infrastructure is unavailable or unreliable it decreases the surgical capacity. The study concluded that many hospitals in Uganda did not meet the surgical indicators provided and needed to improve their infrastructure to increase their surgical capacity.[9]

Another study by Cheelo et al[21] stated that surgical capacity is "one of the most important drivers of global welfare." The researchers focused on surgical capacity specifically at district hospitals in Zambia. The goal was to assess changes in surgical capacity at the hospitals between the years 2013 and 2016. They combined infrastructure with equipment and supplies and specifically identified the number of anesthesia

machines, autoclaves, surgical instruments, and drugs and consumables. Through the assessment, the researchers were able to identify the areas of surgical capacity that needed to scale up to improve surgical service in Zambia.[21] The necessary improvement of infrastructure and working equipment[21] was highlighted in the article to strengthen the surgical outcomes.

A study conducted by Groen et al[22] assessed surgical capacity in Sierra Leone which is located in West Africa. The researchers utilized the personnel, infrastructure, procedure, equipment and supplies (PIPES) survey. Items that were categorized under infrastructure included: number of beds, running water, electricity, generator, incinerator, medical records, emergency department, recovery room, intensive care unit, blood bank, laboratory (to test blood and urine), X-ray machine, ultrasound machine, and computed tomography (CT) scanner.[22] The researchers concluded that the number of operating rooms does make a difference in the surgical outcomes of a hospital.[22]

Stewart et al[23] completed a study in Ghana that investigated the relationship between surgical capacity and outcomes. The researchers utilized the Tool for Situational Analysis to Assess Emergency and Essential Surgical Care (TSAAEESC) provided by the World Health Organization (WHO).[23] The researchers identified four levels of care: primary health centers, district, regional, and tertiary hospitals. Infrastructure included: number of beds and functional operating rooms and/or procedure areas. The researchers discovered that more resources and surgery capability was available at a higher level of care. Improving the infrastructure of trauma units can improve surgical outcomes because of the access to safer and more effective care. The researchers concluded that to better understand the relationship between capacity and outcome a more detailed survey should

be utilized which focuses on barriers to healthcare, structural elements, and healthcare and administration.[23]

An increase in infrastructural elements indicated better surgical outcomes in each of these studies. Assessing surgical capacity must include infrastructure to accurately identify the needs of a hospital.

Equipment and Supplies

A study conducted by Funk et al[24] highlighted the importance of the pulse oximetry as an indicator for safe surgery and anesthesia capabilities. The shortage of surgical services and anesthesia in sub-Saharan Africa and South Asia can negatively affect the surgical outcomes of those countries.[24] The researchers wanted to further understand the differences between operating theaters worldwide so they estimated and compared regional densities across the operating theaters. The pulse oximetry was identified as an essential tool for surgery so the researchers collected data throughout the regions from the World Federation of Societies of Anaesthesiologists (WFSA). The researchers determined that low-income countries had fewer than two operating theaters per 100,000 population and less than half reported having a pulse oximetry. The pulse oximetry was an essential indicator of surgical service so the WHO added it to the Safe Surgery Saves Lives programme (SSSL).[24] The pulse oximetry falls under the equipment and supplies category of surgical capacity and can be used to determine the surgical outcomes of a hospital.

Haglund et al[25] studied surgical capacity building by understanding the importance of surgical equipment for neurosurgery in Uganda. The researchers determined that low-resource countries have poor or no surgical equipment. They

partnered with Duke Global Health Placement of Life-changing Usable Surplus (PLUS) Program which supplies surgical equipment to low-income countries. The goal of the studies was to determine the effect that surgical equipment and training had on the hospitals in Uganda. They collected baseline data of the surgeries performed then implemented the PLUS program. They defined surgical equipment as operating microscopes, high-speed drills, trays with microinstruments, and other specific tools for neurosurgery. After two years, the researchers evaluated the success of the program and discovered that the operating rooms in Ugandan hospitals became more efficient and productive in completing surgeries.[25] Proper equipment and training can effectively increase the surgical capacity of the hospital.

Another study by Khan et al[26] investigated how improving anesthesia safety in low-resource setting can change the effectiveness of a surgery. They stated that globally there is no shortage of equipment but the distribution of the equipment is limited. Their goal is to increase the equitable distribution of equipment to improve global surgical capacity. The authors recognize that safe anesthesia care will prevent loss of life and create better surgical outcomes. They defined proper surgical equipment as "pulse oximeters, capnographs, oxygen concentrators, anesthesia machines, suction apparatus, resuscitation equipment, airway-related equipment, and vaporizers."[26] The researchers concluded that safe anesthesia care during surgery will result in better surgical outcomes however proper equipment is necessary to reach those outcomes.[26]

Li et al[27] conducted a retrospective study in China to understand the challenges of surgical capacity building. Their goal was to specifically identify the current practices in the township hospitals and barriers that affected surgical capacity building. They

surveyed the physicians at the hospitals and discovered the most stated reason that appendectomy surgeries could not be completed was due to the lack of anesthesia services and surgical equipment.[27] The study concluded that improving surgical capacity by adding valuable surgical equipment and anesthesia services is necessary to improving surgical services.[27]

The above studies identified the importance of surgical equipment and its importance in improving surgical capacity.

Procedures

Another key component in surgical capacity is the completion of certain procedures or the skill sets of the surgeons and surgical providers.

One study conducted by Henry et al[28] explored the surgical capacity in southern Nigeria through a survey. Specifically, the researchers identified the surgical capacity of primary and secondary hospitals. The survey included: workforce, infrastructure, skills, equipment and supplies. They separated the skills or procedures into different categories: minor surgery, trauma resuscitation, orthopedic trauma, major surgery, obstetric surgery, pediatric surgery, and anesthesia. The researchers discovered that more specified training for surgeries is necessary such as tracheostomies, repair of imperforate anus, post burn contracture, and repair of obstetric fistula. Untreated burns can cause major disability and children lose more productive life years from burns than injuries in war.[28] Surgical capacity can be strengthened when surgeons have the skills to properly treat the patients.

Another study by Bhashyam et al,[29] researched building global orthopedic surgical capacity through the lens of personnel. The researchers introduced the option of continuing medical education (CME) to build surgical capacity. The study defined CME

"as educational activities that serve to maintain, develop, or increase the knowledge, skills, performance, and relationships that a physician uses to provide services for patients, the public, or the profession."[29] The CME program improves surgical capacity because it gives the surgical providers knowledge on how to better and more efficiently serve their patients. The researchers conducted a needs assessment to determine current skill-level and knowledge of the surgeons and in what areas CME can be used to improve future surgical service. It concluded that CME can be useful in increasing surgical capacity due to the increase of knowledge and skills gained by the surgical providers.[29]

Loveday et al[30] piloted a study that collected data on the emergency and essential surgical care capacity and identified areas for improvement. The study was implemented in Bangladesh which is a country in south Asia. The researchers utilized the WHO Emergency and Essential Surgical Care Situational Analysis Tool (SAT). The SAT defines procedures as interventions which include acute burn management, incision and drainage of abscesses, wound debridement, and male circumcision. The researchers concluded that improving surgical care begins with strengthening poorer areas of the healthcare system including types of interventions completed and personnel to complete those interventions.[30]

A study administered by Markin et al[31] analyzed the surgical capacity in Santa Cruz, Bolivia. The researchers utilized the Spanish version of the PIPES tool to collect data on the surgical capacity of the state healthcare systems. They divided the procedures into two categories: basic procedures routinely performed and basic procedures less frequently performed. The surgeries consist of caesarean section, tubal ligation, incision and drainage, appendectomy, congenital abdominal wall defects, cleft lip and palate,

imperforate anus, clubfoot, skin grafting, laparoscopic surgery, and contracture. The researchers found that all procedures were available but there was a disparity between urban and rural locations. They concluded that the data collected will be used to determine the areas in the Santa Cruz hospital system where surgical capacity can be improved to lessen the gap between rural and urban surgical service.[31]

The above studies communicated the need for improving procedures and skill sets of the physician to improve the surgical capacity of hospitals.

Pediatric Surgical Capacity

There is a difference in the surgical care for children and adults and the following studies identify surgical capacity according to pediatric surgery.

Bickler and Rode[32] essential components for building up pediatric surgical care in developing countries. They identified the top three surgical needs: injuries, congenital abnormalities, and surgical infections. When these are left untreated, children are at a greater risk for disability and mortality. The researchers recommended providing additional training to the surgeons in primary and secondary levels. Also, greater surgical education across the hospital systems would improve the pediatric surgical outcomes.[32] The study focused on education to increase pediatric surgical capacity.

Okoye et al[33] conducted a pilot survey for pediatric surgical capacity using the Pediatric Personnel, Infrastructure, Procedure, Equipment, and Supplies (PediPIPES) tool. The tool was distributed among healthcare facilities in sub-Saharan Africa. The data revealed that the facilities had fewer than two pediatric surgeons in residence, less than half had a functioning Neonatal Intensive Care Unit (NICU), and few owned a pediatric ventilator. More common surgeries were completed but those necessary to fix congenital

anomalies were less frequent. The researchers concluded that the PediPIPES tool was useful in identifying shortages in pediatric surgical capacity.[33]

The Global Initiative for Children's Surgery (GICS) was a collaboration of individuals in pediatric surgery created to recognize areas needing improvement in pediatric surgical care.[34] The GICS categorized surgical capacity development into four groups: research, finance and advocacy, training and education, and infrastructure. The group concluded that each of these areas should increase to improve pediatric surgical care but will only increase through collaborative efforts by the global pediatric healthcare community.[34]

Each of these studies recognized the unique challenge of enhancing pediatric surgical capacity in LMICs. They each defined pediatric surgical capacity using multiple components similarly to the previous studies that focused on general surgical capacity.

Discussion

The need for surgical care in LMICs is necessary to reduce the years of life lost in patients. Surgical capacity is an area of interest that can be used to strengthen the healthcare systems. There are many different definitions of surgical capacity that previous studies have utilized to identify areas needing growth. Most definitions include personnel, infrastructure, procedures, and equipment and supplies. Samuel et al[12] defined surgical capacity "as the ability of a health care system to meet the needs of its population." This definition does not adequately define the areas that surgical capacity covers however it does recognize the end goal is to meet the needs of the population being served.

Most studies utilized the TSAAEESC or the PIPES survey because it encompassed many parts of surgical capacity. Kwon et al[35] utilized the TSAAEESC and concluded, "The surgical capacity scoring index described herein, however, may be able to help the world's hospitals and governments focus their limited resources more effectively for better results in LMICs." These surveys cover all areas of surgical capacity and though they have limitations, they are able to identify areas that governments need to increase to improve surgical capacity. The surveys can be revised to fit specific areas of surgical capacity as well. A study by Cairo et al[36] used a revised version of the PIPES survey to assess hospitals' pediatric surgical capacity through the PediPIPES survey. The revisions occur based on the items represented in each category but the surveys still collect data on personnel, infrastructure, procedures, and equipment and supplies.

Many articles concluded that a combination of the surgical capacity classifications is necessary to wholly improve the surgical care systems in LMICs. Articles that focused on personnel such as surgeons, obstetricians, and anesthesiologist also looked at training and skills of the personnel to provide the necessary surgical care. Bhashyam et al[29] combines personnel with procedures/skills to define surgical capacity to create an improved healthcare system for the population of interest. Loveday et al[30] also combined personnel and procedures to describe surgical capacity. The researchers acknowledge the importance of obtaining the numbers needed to serve the population but also the skills required to properly serve them and improve surgical outcomes. Another study by Haglund et al[25] emphasized the importance of training surgical workers to properly use supplies and equipment. The combination of skills and equipment reveals that surgical capacity is best approached at multiple levels.

The assessment of surgical capacity is necessary to identify the areas that need improvement to meet the LCoGS indicators. A study by Anderson et al[37] conducted a baseline assessment of surgical capacity to identify areas of improvement to reach the LCoGS indicators in the future. They separated their surgical capacity groups by infrastructure, workforce, finance, and surgical delivery.[37] These groups are different than most of the researchers that utilized the above surveys. If the LCoGS indicators are the goal, then it might be useful to categorize surgical capacity based off the indicators. Anderson et al[37] concluded that the assessment will be used to inform a future national surgical plan in Nigeria. Surgical capacity assessments are used to inform governments for future plans and to identify areas for improvement.

There are limitations to completing surgical capacity assessments. Many assessments use surveys with specific questions which are calculated into a final score that determines surgical capacity of the country of interest. This is a problem because some hospitals cannot properly answer each question out which causes missing data and a biased conclusion.[35] LMICs are already struggling to provide proper workforce so to allocate an individual to collect data for a surgical capacity assessment is difficult which can result in a loss of data for the assessment.[37] Finally, assessments can be lengthy and detailed which requires time to fill out. The time spent completing the survey might be utilized in a better way for the hospital staff. Despite each of these limitations a surgical capacity assessment should be completed because it enables healthcare systems and governments to identify specific areas to further increase the surgical services for the designated population.

Conclusion

Surgical Capacity covers many areas of a healthcare system and it is necessary to identify each one of those. Personnel, infrastructure, procedures, equipment and supplies are equally important in strengthening surgical capacity. Specifically, a pediatric focused survey will be the most useful to identify the pediatric surgical need of a country.

The following study will use each of these categories to identify where Somaliland hospitals need to increase their pediatric surgical capacity to effectively complete the Bellwethers surgeries for the pediatric population and to determine its influence on the completion of emergent or elective pediatric surgeries.

CHAPTER THREE

Methods

Research Question

The study was conducted to determine whether there is a relationship between the surgical capacity of Somaliland hospitals and the type of pediatric surgery completed (i.e. emergent or elective surgery). The null hypothesis is that there is no relationship between surgical capacity and type of pediatric surgery completed. To answer this question, the researchers will identify the current surgical capacity of the participating Somaliland hospitals and what pediatric surgeries were completed in these hospitals.

Study Design

The study conducted to understand the relationship between surgical capacity and type of pediatric surgery was a quantitative retrospective design. This design was selected because the researchers could identify the current surgical capacity of the participating hospitals through surgical capacity surveys. Also, it allowed for recent data on pediatric surgeries to be collected and analyzed from surgical records from the participating hospitals. Other reasons for choosing a retrospective design is that it is cost effective and it does not require many years to be completed. However, there are limitations to this design. It does not allow for tracking changes over time or identifying the temporal relationship between surgical capacity and type of pediatric surgery.

Participants

The study was implemented in the country of Somaliland which is located in east Africa. There are currently only sixteen hospitals in the country. The country has the fourth lowest Gross Domestic Product (GDP) according to the World Bank.[3] The low GDP currently does not allow funding to be allocated to the surgical care of the pediatric population. However, there is a great pediatric surgical need because in Low to Middle Income Countries (LMICs) 50% of the population is children.[1]

Somaliland hospitals were asked to complete surgical capacity surveys and of the sixteen hospitals in the country, fifteen agreed to participate in the study. Each hospital completed the survey to the best knowledge of their current surgical capacity. Data on pediatric surgeries was collected and only surgeries that occurred in the fifteen participating hospitals were utilized in the study. Children between the ages of zero to fourteen years that had surgery within the one-year time frame of the study were selected. The age range was defined by the original data collectors. Those that had surgery outside of the timeline, not within the age range, or in a non-participating hospital were excluded from the study.

Instruments

There were two different surveys utilized to collect data for hospital surgical capacity and pediatric surgeries completed in each hospital.

Somaliland Hospital Capacity Assessment

The hospital surgical capacity survey was called Somaliland Hospital Capacity Assessment (SHCA) (Appendix C). It identified surgical capacity of hospitals in four

sections. Section 1 consisted of general information such as location of hospital, type of hospital, and hospital level. The second section, infrastructure, compiled information including water, internet, and electricity availability, and number of hospital beds. The third section was service delivery which recorded number of surgical personnel, surgeries completed, and population served. The final section covered hospital finances. The data for the hospitals was collected between August 2016 and July 2017. For the purpose of this study, the financial section was excluded from the analysis.

Somaliland Pediatric Surgical Review Tool

The second tool was the Somaliland pediatric surgical record review tool (SPSRRT) (Appendix D). The survey was given to each hospital to record information about the children who received surgery. It was split into five sections: hospital information, patient demographics, surgery information, admission information, and financial information of the patient. The hospitals collected a total of 1,255 pediatric surgeries and the information on each surgery.

Procedures

The first data set consisted of results from the SHCA of the fifteen hospitals. The data collectors went to each hospital willing to participate and asked them to fill out the survey. The hospital director or manager would fill out the survey section by section to the best of their knowledge about the hospital's capacity. The completed surveys were sent to a single data collector to be organized and inputted into a data file. The final data file was imported for data analysis.

The second dataset was the pediatric surgeries with 1,255 pediatric surgeries. The data collectors went to each hospital and searched previous surgical records from 01 August 2016 to 31 July 2017. They extracted the surgical information on each participant using the SPSRRT. The information was compiled into one final data set on pediatric surgeries.

In the study, surgical capacity in the hospitals was defined by the bellwethers procedures. If the hospital could complete a cesarean section, laparotomy, and fracture setting, then they had adequate surgical capacity. Emergent surgery was defined as, the result of not receiving the surgery, is fatal. Elective surgery was defined as, receiving the surgery, will improve quality of life but it is not fatal if not received.

Data Analysis

The statistical analysis of this study was completed using SAS version 9.4 (English) software (SAS). Any missing pediatric surgery data was accounted for through imputation methods which were conducted by the original data collector. Only one of ten sets created was used for further analysis. Both the hospital capacity and pediatric surgery data sets were imported into SAS.

AIM 1 was to determine the current surgical capacity of hospitals in Somaliland. Hospital variables were arranged in two categories: continuous and categorical. A procedure frequency (proc freq) and procedure means (proc means) was utilized to discover the current hospital characteristics. The results were arranged in a table in four sections: Hospital Description, Infrastructure, Surgeries, and Personnel. A similar analysis was completed to determine hospitals characteristics for each region in Somaliland.

AIM 2 was to identify the pediatric surgeries completed in each participating hospital. The pediatric data set required creating a hospital variable to allow for both hospital and pediatric data sets to be combined. The 1,255 pediatric surgeries were organized by hospital using proc freq and proc means.

AIM 3 was to determine what factors of surgical capacity influence completion of emergent or elective pediatric surgeries. Before running an analysis for AIM 3, a few analysis procedures were necessary. A procedure frequency chi square (proc freq chi square) was used to analyze what hospital characteristics affected completion of bellwether procedures (cesarean section, laparotomy, and fracture setting). A procedure t-test (proc t-test) was applied to understand the influence that personnel had on completing the bellwethers procedures. An additional proc freq chi square was used to understand the influence that surgical capacity had on completion of specific types of surgical conditions. Each of the pediatric surgeries were placed into 13 categories: Congenital Anomalies (cleft lip, cleft palate, club foot, hydrocephalus, spina bifida), Tonsillitis, Trauma/wound/snake, Eye, Abdominal, Bone, Abscess, Contracture, Hematoma, Mass, Other, Bacterial Infection, Unknown.

A principal component analysis (PCA) was run using a procedure factor (proc factor). Variables were categorized into four components of surgical capacity: equipment, personnel, infrastructure, and surgical delivery. A primary factor was identified for each component and was created into a new variable. The four new variables were added to the final analysis.

Finally, AIM 3 was completed by running a procedure logistic (proc logistic) to determine if surgical capacity influenced whether elective or emergent surgery was completed.

Limitations

There were limitations to the methodology of the study. The data had been collected retrospectively from hospital records that had missing data which could skew the results. However, the data was run through an imputation method to produce as accurate results as possible. There are only sixteen hospitals in Somaliland and only fifteen participated which is a small sample size that can affect the power of the statistical analysis.

The definition of surgical capacity was defined by the bellwethers procedures which is a limitation for identifying pediatric surgical capacity. The bellwethers procedures are an adult metric and there is not currently a pediatric bellwethers metric. If pediatric bellwether procedures were created, this study should be reanalyzed to confirm the previous conclusion.

CHAPTER FOUR

Results

Hospital Surgical Capacity

The surgical capacity of each Somaliland hospital was identified and organized by hospital description, infrastructure, surgeries, surgical delivery, and personnel (Table 4.1).

Hospital Description

Hospital description labeled, location, type, and level of hospitals in Somaliland. Out of the fifteen hospital, six are located in Maroodi Jeex/ Hargeisa, three in Awdal/Boroma, two in Toghdeer/ Burao, one in Sahil/ Sheikh, one in Sahil/ Berbera, one in Maroodi Jeex/ Gabiley, and one in Sanaag/ Erigabo. There are three different types of hospitals in Somaliland: public/ government, private, and Non-Governmental Organization (NGO)/ Charity. Eight Hospitals are public/ government owned, six are privately owned, and Edna Adan University hospital (EAUH) is the only NGO/ Charity hospital. Each hospital was classified as first, second, or third level hospital. Only Mohamed Aden Sheikh Children's Teaching Hospital (MASCTH) is classified as a first level hospital. Seven are classified as second level and seven are third level hospitals.

Infrastructure

The infrastructure of each hospital was categorized by the availability of electricity, water, internet, phone, generator, and oxygen, the number of beds, and

Table 4.1

Characteristics of each hospital in Somaliland

Region	Total (n)	(Mean/ Mode)	Maroodi Jeex						
Hospital Name			edna adan university hospital %(n)	mohamed aden sheikh children's teaching hospital %(n)	hargeisa group hospital %(n)	gargaar multispecialty hospital %(n)	manhal specialty hospital %(n)	hargeisa neurology hospital %(n)	gabiley regional hospital %(n)
Hospital Description									
Type of Hospital			NGO/ charity	public/ gov	public/ gov	private	private	private	public/ gov
Surgical Delivery									
Average patients admitted per month	4819	321.27	8% (400)	1% (60)	12% (580)	25% (1200)	5% (240)	3% (130)	2% (100)
Average pediatric patients admitted per month	707	54.38	9% (63)	8% (60)	- -	28% (200)	1% (08)	2% (15)	3% (20)
Average number of operations per month	1162	77.47	2% (26)	0% (00)	17% (200)	19% (220)	17% (200)	1% (15)	2% (20)
Average number of pediatric operations per month	65	5.42	5% (03)	0% (00)	26% (17)	14% (09)	12% (08)	3% (02)	0% (00)
Infrastructure electricity availability (%)		100	100	100	100	100	100	100	100
reliance on generator (%)		1-25	1-25	1-25	-	1-25	100	0 (never)	1-25

(Continued)

Region	Total (n)	(Mean/ Mode)	Maroodi Jeex							
water availability (%)		100	100	100	100	100	100	100	100	
internet availability (%)		76-99	76-99	100	76-99	76-99	100	76-99	76-99	
phone availability (%)		100	100	100	100	100	100	100	100	
oxygen availability (%)		76-99	100	100	100	76-99	100	76-99	76-99	
Number of hospital beds	1769	117.93	5% (80)	2% (44)	28% (500)	6% (100)	4% (62)	2% (30)	6% (102)	
Number of pediatric hospital beds	260	17.333	31% (20)	17% (44)	12% (32)	3% (07)	0% (00)	2% (05)	8% (20)	
Number of functional operating rooms	39	2.6	5% (03)	0% (00)	13% (05)	13% (05)	13% (05)	8% (03)	5% (02)	
number of functional anesthesia machines	33	2.2	8% (05)	0% (00)	9% (03)	12% (04)	6% (02)	6% (02)	6% (02)	
number of functional ventilators	7	0.4667	5% (03)	0% (00)	14% (01)	0% (00)	43% (03)	0% (00)	0% (00)	
Surgeries										
average number of laparotomies performed per month	62.825	4.1883	1% (0.66)	0% (00)	8% (05)	3% (02)	18% (11)	0% (00)	2% (01)	
average number of C-sections performed per month	319	21.267	31% (20)	0% (00)	22% (70)	31% (100)	0% (00)	0% (00)	5% (15)	
average number of open fracture repairs performed per month	169	11.267	0% (00)	0% (00)	19% (32)	18% (30)	18% (30)	0% (00)	0% (00)	

(Continued)

Region	Total (n)	(Mean/ Mode)	Maroodi Jeex													
Personnel																
number of surgeons	37	2.4667	3%	(02)	0%	(00)	11%	(04)	16%	(06)	22%	(08)	3%	(01)	5%	(02)
Number of pediatric surgeons	1	0.0667	2%	(01)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)
non-surgeon available to perform surgery		always	always		never		always		always		always		never		always	
non_anesthesiologist availability to provide anesthesia		always	always		never		always		always		always		sometimes		always	
number of anesthesiologist	3	0.2	0%	(00)	0%	(00)	0%	(00)	33%	(01)	33%	(01)	0%	(00)	0%	(00)
number of pediatric anesthesiologists	0	0	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)
number of anesthetist	42	2.8	5%	(03)	0%	(00)	26%	(11)	7%	(03)	7%	(03)	2%	(01)	2%	(01)
number of obstetricians	13	0.8667	3%	(02)	0%	(00)	23%	(03)	15%	(02)	0%	(00)	0%	(00)	8%	(01)
number of nurses	473	31.533	60%	(39)	3%	(15)	26%	(125)	6%	(28)	3%	(14)	3%	(12)	3%	(14)

(Continued)

Region	Toghdeer		Awdal			Sahil		Sanaag
Hospital Name	daarul xanan hospital %(n)	burao regional hospital %(n)	alaale hospital (boroma fistula hospital) %(n)	boroma regional hospital %(n)	al hayat hospital %(n)	sheikh district hospital %(n)	berbera regional hospital %(n)	erigabo regional hospital %(n)
Hospital Description								
Type of Hospital	private	public/ gov	private	public/ gov	private	public/ gov	public/ gov	public/ gov
Surgical Delivery								
Average patients admitted per month	6%(300)	11%(519)	3%(130)	8%(400)	4%(180)	4%(180)	4%(200)	4%(200)
Average pediatric patients admitted per month	1%(10)	15%(109)	--	15%(106)	0%(0)	8%(55)	7%(46)	2%(15)
Average number of operations per month	4%(50)	8%(93)	7%(80)	9%(100)	6%(70)	4%(45)	1%(13)	3%(30)
Average number of pediatric operations per month	3%(02)	0%(00)	--	--	15%(10)	--	18%(12)	3%(02)
Infrastructure								
electricity availability (%)	76-99	100	100	100	100	76-99	100	76-99
reliance on generator (%)	0 (never)	1-25	1-25	1-25	1-25	1-25	1-25	1-25
water availability (%)	100	100	100	100	100	100	100	100
internet availability (%)	76-99	76-99	76-99	76-99	76-99	76-99	76-99	76-99

(Continued)

Regions	Toghdeer				Awdal				Sahil				Sanaag			
phone availability (%)	100		76-99		100		100		100		76-99		100		100	
oxygen availability (%)	76-99		51-75		76-99		76-99		76-99		76-99		51-75		76-99	
Number of hospital beds	2%	(39)	10%	(171)	4%	(73)	8%	(150)	6%	(100)	2%	(38)	10%	(180)	6%	(100)
Number of pediatric hospital beds	2%	(04)	8%	(20)	5%	(12)	12%	(30)	8%	(20)	2%	(06)	8%	(20)	8%	(20)
Number of functional operating rooms	3%	(01)	5%	(02)	8%	(03)	5%	(02)	8%	(03)	5%	(02)	5%	(02)	3%	(01)
number of functional anesthesia machines	3%	(01)	3%	(01)	15%	(05)	6%	(02)	9%	(03)	3%	(01)	3%	(01)	3%	(01)
number of functional ventilators	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)
Surgeries																
average number of laparotomies performed per month	5%	(03)	3%	(02)	16%	(10)	8%	(05)	32%	(20)	0%	(00)	0%	(0.17)	5%	(03)
average number of C-sections performed per month	8%	(25)	8%	(26)	5%	(15)	4%	(13)	3%	(10)	2%	(05)	3%	(10)	3%	(10)
average number of open fracture repairs performed per month	0%	(00)	0%	(00)	0%	(00)	18%	(30)	24%	(40)	0%	(00)	0%	(00)	4%	(07)
Personnel																
number of surgeons	5%	(02)	5%	(02)	8%	(03)	5%	(02)	3%	(01)	3%	(01)	0%	(00)	8%	(03)
Number of pediatric surgeons	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)
non-surgeon available to perform surgery	always		always		always		always		always		always		always		always	
non_anesthesiologist availability to provide anesthesia	always		always		always		always		always		always		always		always	
number of anesthesiologist	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	33%	(01)
number of pediatric anesthesiologists	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)	0%	(00)
number of anesthetist	2%	(01)	17%	(07)	2%	(01)	2%	(01)	12%	(05)	2%	(01)	5%	(02)	5%	(02)
number of obstetricians	8%	(01)	8%	(01)	8%	(01)	8%	(01)	0%	(00)	0%	(00)	0%	(00)	8%	(01)
number of nurses	3%	(16)	10%	(47)	3%	(12)	6%	(27)	5%	(25)	2%	(11)	4%	(18)	15%	(70)

functional operating rooms, anesthesia machines, and ventilators. Three hospitals have 76-99% electricity availability and twelve have 100% electricity availability. Daarul Xanan Hospital (DXH) and Hargeisa Neurology Hospital (HNH) never relied on a generator, eleven relied on a generator 1-25% of the time, and Manhal Specialty Hospital (MSH) relied on a generator 100% of the time. All fifteen hospitals have 100% water availability. Thirteen hospitals have 76-99% internet availability and MASCTH and MSH have internet available 100% of the time. Sheikh District Hospital (SDH) and Burao Regional Hospital (BuRH) are the only hospitals that have phone availability <100%. BuRH and Berbera Regional Hospital (BeRH) have 51-75% oxygen availability, nine hospitals have 76-99% oxygen availability, and four hospitals have 100% oxygen availability. HNH has the lowest number of hospital beds at 30 and Hargeisa Group Hospital (HGH) has the highest number at 500 beds. MSH has zero pediatric beds and MASCTH has 44 pediatric beds. The average number of functional operating rooms is 2.6, functional anesthesia machines is 2.2, and functional ventilators is 0.4667. Most of the hospitals do not have a functional ventilator.

Surgeries

The type and number of surgeries performed were identified in each hospital. The average number of cesarean sections, laparotomies, and fracture repairs conducted per month were recorded. Boroma Regional Hospital (BoRH) had the highest average number of laparotomies performed per month at 20 laparotomies per month. Three hospitals did not complete any laparotomies within the time period. Gargaar Multispecialty Hospital (GMH) completed the highest average number of cesarean

sections at 100 per month. Three hospitals did not complete any cesarean sections within the time period. Al Hayat Hospital (AHH) performed the highest average number of fracture repairs at 40 per month. The average number or post-operative death for all hospitals is 0.9595 deaths per month.

Surgical Delivery

The average number of patients admitted per month was 4,819. GMH admitted the highest number of patients per month (n=1200) and the highest number of pediatric patients per month (n=200). GMH completed the most operations per month (n=220) and HGH completed the most pediatric operations per month (n=17).

Personnel

The final section determined the providers in the hospital. MSH had eight surgeons which is the most out of the fifteen hospitals. The total number of surgeons in the country is 37. EAUH has the only pediatric surgeon within the country. MASCTH and HNH never have non-surgeons available for surgery whereas all the other hospitals always have non-surgeons available for surgery. MASCTH never have non-anesthesiologist available to administer anesthesia. HNH sometimes has non-anesthesiologist available to administer anesthesia. All other hospitals have non-anesthesiologists available to administer anesthesia. There are only three anesthesiologists in Somaliland. There are 42 anesthetists and HGH has the most anesthetists (n=11). There is a total of thirteen obstetricians out of the fifteen hospitals. There are 473 nurses and the most at HGH having 125 nurses.

Regional Surgical Capacity

Each of the hospitals were placed into five regions: Maroodi Jeex, Toghdeer, Awdal, Sahil, and Sanaag. A table was created to identify the surgical capacity of each region in Somaliland (Table 4.2).

Region Description

The region of Maroodi Jeex contained seven of the fifteen hospitals. The only NGO/ charity hospital in Somaliland is in this region. Over 50% of operations and admissions occur in this region. It is the only region that has a ventilator available for surgery. The surgical care providers in this region perform over 50% of the C-sections and fracture repairs in the country and it is the only region that has a pediatric surgeon. Over 50% of surgical personnel work in Maroodi Jeex.

Toghdeer has only two hospitals that are 2nd level hospitals. It records the second highest admission per month for adults and pediatrics. The surgical personnel perform the second highest C-sections per month in the country.

Awdal has three hospitals and two are private hospitals. It reports the second highest adult operations per month in Somaliland. The Awdal surgical personnel perform the highest number of laparotomies per month and the second highest number of fracture repairs per month. The region has the second highest number of surgeons available to provide surgical care.

Sahil has two government hospitals available for surgical care. It records the second highest pediatric operations per month in Somaliland. Out of the three surgeries, it reported only completing 5% of the total C-sections and no other surgeries. It only has one surgeon, three anesthetists, and 29 nurses available for surgery.

Table 4.2.

Hospitals Characteristics by Region

Region	Total (n)	(Mean/Mode)	Maroodi Jeex %(n)	Toghdeer %(n)	Awdal %(n)	Sahil %(n)	Sanaag %(n)
Number of Hospitals	15	3	47% (7)	13% (2)	20% (3)	13% (2)	7% (1)
Hospital Description							
Type of Hospital							
public/government	8		38% (3)	13% (1)	13% (1)	25% (2)	13% (1)
private	6		50% (3)	17% (1)	33% (2)	0% (0)	0% (0)
NGO/charity	1		100% (1)	0% (0)	0% (0)	0% (0)	0% (0)
Surgical Delivery							
Average patients admitted per month	4819	963.8	56% (2710)	17% (819)	15% (710)	8% (380)	4% (200)
Average pediatric patients admitted per month	707	141.4	52% (366)	17% (119)	15% (106)	14% (101)	2% (15)
Average number of operations per month	1162	232.4	59% (681)	12% (143)	22% (250)	5% (58)	3% (30)
Average number of pediatric operations per month	65	13	60% (39)	3% (2)	15% (10)	18% (12)	3% (2)

(Continued)

Region	Total (n)	(Mean/ Mode)	Maroodi Jeex %(n)		Toghdeer %(n)		Awdal %(n)		Sahil %(n)		Sanaag %(n)	
Infrastructure												
electricity availability (%)												
76-99	3	0.6	0%	(0)	33%	(1)	0%	(0)	33%	(1)	33%	(1)
100	12	2.4	58%	(7)	8%	(1)	25%	(3)	8%	(1)	0%	(0)
reliance on generator (%)												
0	2	0.4	50%	(1)	50%	(1)	0%	(0)	0%	(0)	0%	(0)
1-25	11	2.2	36%	(4)	9%	(1)	27%	(3)	18%	(2)	9%	(1)
100	1	0.2	100%	(1)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
water availability (100%)	15	3	47%	(7)	13%	(2)	20%	(3)	13%	(2)	7%	(1)
internet availability (%)												
76-99	13	2.6	38%	(5)	15%	(2)	23%	(3)	15%	(2)	8%	(1)
100	2	0.4	100%	(2)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
phone availability (%)												
76-99	2	0.4	0%	(0)	50%	(1)	0%	(0)	50%	(1)	0%	(0)
100	13	2.6	54%	(7)	8%	(1)	23%	(3)	8%	(1)	8%	(1)
oxygen availability (%)												
51-75	2	0.4	0%	(0)	50%	(1)	0%	(0)	50%	(1)	0%	(0)
76-99	9	1.8	33%	(3)	11%	(1)	33%	(3)	11%	(1)	11%	(1)
100	4	0.8	100%	(4)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
Number of hospital beds	1769	353.8	52%	(918)	12%	(210)	18%	(323)	12%	(218)	6%	(100)
Number of pediatric hospital beds	260	52	49%	(128)	9%	(24)	24%	(62)	10%	(26)	8%	(20)
Number of functional operating rooms	39	7.8	59%	(23)	8%	(3)	21%	(8)	10%	(4)	3%	(1)
Number of functional anesthesia machines	33	6.6	55%	(18)	6%	(2)	30%	(10)	6%	(2)	3%	(1)
Number of functional ventilators	7	1.4	100%	(7)	0%	(0)	0%	(0)	0%	(0)	0%	(0)

(Continued)

Region	Total (n)	(Mean/ Mode)	Maroodi Jeex %(n)		Toghdeer %(n)		Awdal %(n)		Sahil %(n)		Sanaag %(n)	
Surgeries												
average number of laparotomies performed per month	62.825	12.565	31%	(20)	8%	(5)	56%	(35)	0%	(0)	5%	(3)
average number of C-sections performed per month	319	63.8	64%	(205)	16%	(51)	12%	(38)	5%	(15)	3%	(10)
average number of open fracture repairs performed per month	169	33.8	54%	(92)	0%	(0)	41%	(70)	0%	(0)	4%	(7)
Personnel	0											
number of surgeons	37	7.4	62%	(23)	11%	(4)	16%	(6)	3%	(1)	8%	(3)
Number of pediatric surgeons	1	0.2	100%	(1)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
non-surgeon available to perform surgery												
never	2	0.4	100%	(2)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
always	13	2.6	38%	(5)	15%	(2)	23%	(3)	15%	(2)	8%	(1)
non_anesthesiologist availability to provide anesthesia												
never	1	0.2	100%	(1)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
sometimes	1	0.2	100%	(1)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
always	13	2.6	38%	(5)	15%	(2)	23%	(3)	15%	(2)	8%	(1)
number of anesthesiologist	3	0.6	67%	(2)	0%	(0)	0%	(0)	0%	(0)	33%	(1)
number of pediatric anesthesiologists	0	0	0%	(0)	0%	(0)	0%	(0)	0%	(0)	0%	(0)
number of anesthetist	42	8.4	52%	(22)	19%	(8)	17%	(7)	7%	(3)	5%	(2)
number of obstetricians	13	2.6	62%	(8)	15%	(2)	15%	(2)	0%	(0)	8%	(1)
number of nurses	473	94.6	52%	(247)	13%	(63)	14%	(64)	6%	(29)	15%	(70)

Sanaag has one public hospital and one functional operating room with a functioning anesthesia machine. It has three surgeons and the only anesthesiologist outside of Maroodi Jeex. It has the second highest number of nurses available for surgical care.

Pediatric Surgeries

There were 1255 pediatric surgeries completed from 2016 to 2017. The surgeries were organized by hospital, gender, age, provider of surgery, provider of anesthesia, and outcome of surgery (see Table 4.3). Of the 1,255 surgeries recorded, Gabiley Regional Hospital (GRH) and MASCTH did not complete any pediatric surgeries.

Gender

A total of 706 males, 538 females, and 11 unknown children received surgery in one of the 14 hospitals. MSH, EAUH, and HGH had the highest number of pediatric surgeries at 344, 299, and 183 surgeries.

Age

The age variable was categorized into age ranges: less than one year, 1-5 years, 6-10 years, and 11-14 years. For children less than a year, 259 surgeries were completed, 1-5 years, 315 surgeries were completed, 6-10 years, 363 surgeries were completed, and 11-14 years, 220 surgeries were completed. EAUH completed the most surgeries for children less than one year at 55.6%. MSH performed the most surgeries for the other age categories at 93 surgeries for ages 1-5 years, 131 surgeries for ages 6-10 years, and 83 surgeries for ages 11-14 year.

Table 4.3.

Characteristics of each pediatric surgery by hospital

Region	Total (n)	Mean	Maroodi Jeex													
			edna adan university hospital %(n)		mohamed aden sheikh children's teaching hospital %(n)		hargeisa group hospital %(n)		gargaar multispecialty hospital %(n)		manhal specialty hospital %(n)		hargeisa neurology hospital %(n)		gabiley regional hospital %(n)	
Number of surgeries performed	1255	83.67	24.1%	(303)	-	-	14.7%	(185)	8.8%	(110)	27.4%	(344)	1.0%	(12)	-	-
Gender																
male	706	47.07	23.7%	(167)	-	-	15.0%	(106)	7.8%	(55)	27.9%	(197)	0.8%	(6)	-	-
female	538	35.87	24.5%	(132)	-	-	14.3%	(77)	9.3%	(50)	27.3%	(147)	1.1%	(6)	-	-
unknown	11	0.73	36.4%	(4)	-	-	18.2%	(2)	45.5%	(5)	0.0%	(0)	0.0%	(0)	-	-
Age																
<1	259	17.27	55.6%	(144)	-	-	7.3%	(19)	17.8%	(46)	5.8%	(15)	0.0%	(0)	-	-
1-5 years	315	21.00	23.8%	(75)	-	-	14.0%	(44)	9.2%	(29)	29.5%	(93)	0.0%	(0)	-	-
6-10 years	363	24.20	11.8%	(43)	-	-	19.3%	(70)	5.0%	(18)	36.1%	(131)	0.3%	(1)	-	-
11-15 years	230	15.33	13.5%	(31)	-	-	16.5%	(38)	4.3%	(10)	36.1%	(83)	1.7%	(4)	-	-
unknown	88	5.87	11.4%	(10)	-	-	15.9%	(14)	8.0%	(7)	25.0%	(22)	8.0%	(7)	-	-
Provider of surgery																
nurse	0	0.00	0.0%	(0)	-	-	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	-	-
physician	7	0.47	28.6%	(2)	-	-	0.0%	(0)	71.4%	(5)	0.0%	(0)	0.0%	(0)	-	-
surgeon	1204	80.27	22.3%	(269)	-	-	15.3%	(184)	8.7%	(105)	28.4%	(342)	0.7%	(9)	-	-
pediatric surgeon	2	0.13	0.0%	(0)	-	-	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	-	-
other	4	0.27	0.0%	(0)	-	-	0.0%	(0)	0.0%	(0)	50.0%	(2)	0.0%	(0)	-	-
unknown	38	2.53	84.2%	(32)	-	-	2.6%	(1)	0.0%	(0)	0.0%	(0)	7.9%	(3)	-	-

(Continued)

Region	Total (n)	Mean	Maroodi Jeex													
Provider of anesthesia																
anesthesiologist	155	10.33	0.0%	(0)	-	-	5.8%	(9)	10.3%	(16)	82.6%	(128)	1.3%	(2)	-	-
anesthetist	1058	70.53	25.6%	(271)	-	-	16.5%	(175)	9.2%	(97)	23.2%	(245)	0.7%	(7)	-	-
nurse	1	0.07	0.0%	(0)	-	-	0.0%	(0)	0.0%	(0)	0.0%	(0)	100.0%	(1)	-	-
clinical officer	0	0.00	0.0%	(0)	-	-	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	-	-
other	63	4.20	0.0%	(0)	-	-	4.8%	(3)	11.1%	(7)	25.4%	(16)	4.8%	(3)	-	-
Outcome of Surgery																
alive	631	42.07	20.3%	(128)	-	-	0.0%	(0)	0.0%	(0)	33.9%	(214)	0.0%	(0)	-	-
death	2	0.13	50.0%	(1)	-	-	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	-	-
unknown	275	18.33	52.4%	(144)	-	-	44.7%	(123)	0.0%	(0)	0.0%	(0)	0.0%	(0)	-	-

(Continued Regions)

Region	Toghdeer				Awdal						Sahil				Sanaag	
	daarul xanan hospital %(n)		burao regional hospital %(n)		alaale hospital (boroma hospital) %(n)		boroma regional hospital %(n)		al hayat hospital %(n)		sheikh district hospital %(n)		berbera regional hospital %(n)		erigabo regional hospital %(n)	
Number of surgeries performed	0.2%	(2)	3.0%	(38)	10.5%	(132)	0.7%	(9)	7.9%	(99)	1.3%	(16)	0.2%	(3)	0.2%	(2)
Gender																
male	0.0%	(0)	4.0%	(28)	8.5%	(60)	1.0%	(7)	9.6%	(68)	1.1%	(8)	0.3%	(2)	0.3%	(2)
female	0.4%	(2)	1.9%	(10)	13.4%	(72)	0.4%	(2)	5.8%	(31)	1.5%	(8)	0.2%	(1)	0.0%	(0)
unknown	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
Age																
<1	0.0%	(0)	2.3%	(6)	0.0%	(0)	0.0%	(0)	10.8%	(28)	0.0%	(0)	0.0%	(0)	0.4%	(1)
1-5 years	0.0%	(0)	4.8%	(15)	4.8%	(15)	0.6%	(2)	11.4%	(36)	1.3%	(4)	0.6%	(2)	0.0%	(0)
6-10 years	0.0%	(0)	3.0%	(11)	17.1%	(62)	1.1%	(4)	5.0%	(18)	1.1%	(4)	0.3%	(1)	0.0%	(0)
11-15 years	0.4%	(1)	1.3%	(3)	17.4%	(40)	0.9%	(2)	6.1%	(14)	1.3%	(3)	0.0%	(0)	0.4%	(1)
unknown	1.1%	(1)	3.4%	(3)	17.0%	(15)	1.1%	(1)	3.4%	(3)	5.7%	(5)	0.0%	(0)	0.0%	(0)
Provider of surgery																
nurse	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
physician	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
surgeon	0.2%	(2)	3.2%	(38)	11.0%	(132)	0.7%	(9)	8.1%	(97)	1.3%	(16)	0.1%	(1)	0.0%	(0)
pediatric surgeon	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	100.0%	(2)	0.0%	(0)	0.0%	(0)	0.0%	(0)
other	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	50.0%	(2)	0.0%	(0)
unknown	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.3%	(2)

(Continued)

Region	Toghdeer				Awdal				Sahil				Sanaag	
Provider of anesthesia														
anesthesiologist	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
anesthetist	0.2%	(2)	1.8%	(19)	12.5%	(132)	0.9%	(9)	9.2%	(97)	0.1%	(1)	0.3%	(3)	0.0%	(0)
nurse	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
clinical officer	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
other	0.0%	(0)	30.2%	(19)	0.0%	(0)	0.0%	(0)	0.0%	(0)	23.8%	(15)	0.0%	(0)	0.0%	(0)
Outcome of Surgery														
alive	0.0%	(0)	5.4%	(34)	20.9%	(132)	1.4%	(9)	15.5%	(98)	2.5%	(16)	0.0%	(0)	0.0%	(0)
death	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	50.0%	(1)	0.0%	(0)	0.0%	(0)	0.0%	(0)
unknown	0.7%	(2)	1.5%	(4)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.7%	(2)	0.0%	(0)

Provider of Surgery

There were 1204 surgeries completed by a surgeon, 7 by a physician, 2 by a pediatric surgeon, and 4 by another healthcare provider. MSH had 342 surgeries completed by a surgeon and two completed by another healthcare professional. AHH had the only two surgeries performed by a pediatric surgeon.

Provider of Anesthesia

An anesthesiologist administered anesthesia for 155 pediatric surgeries. MSH had the most surgeries accompanied by an anesthesiologist at 128 surgeries. An anesthetist administered anesthesia at 1,058 pediatric surgeries. EAUH had the most surgeries accompanied by an anesthetist at 271 surgeries. One surgery at HNH had a nurse administer anesthesia. Other healthcare professionals administered anesthesia for 63 surgeries.

Outcome of Surgery

The outcomes of the 1,255 surgeries were 631 alive, 2 dead, and 275 had unknown outcomes. EAUH and HGH had the highest number of unknown outcomes at 144 and 123 surgeries. The two deaths occurred at EAUH and AHH. MSH and Alaale Hospital (AH) had the highest number of only alive outcomes at 214 and 142.

Pediatric Surgery by Region

Each of the surgeries were categorized by the five regions: Maroodi Jeex, Toghdeer, Awdal, Sahil, and Sanaag (Table 4.4).

Table 4.4.

Characteristics of each pediatric surgery by region

Region	Total (n)	Mean	Maroodi Jeex %(n)	Toghdeer %(n)	Awdal %(n)	Sahil %(n)	Sanaag %(n)
Number of surgeries performed	1255	251	76.0% (954)	3.2% (40)	19% (240)	1.5% (19)	0.2% (2)
Gender							
male	706	141.2	75.2% (531)	4.0% (28)	19% (135)	1.4% (10)	0.3% (2)
female	538	107.6	76.6% (412)	2.2% (12)	20% (105)	1.7% (9)	0.0% (0)
unknown	11	2.2	100.0% (11)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
Age							
<1	259	51.8	86.5% (224)	2.3% (6)	11% (28)	0.0% (0)	0.4% (1)
1-5 years	315	63	76.5% (241)	4.8% (15)	17% (53)	1.9% (6)	0.0% (0)
6-10 years	363	72.6	72.5% (263)	3.0% (11)	23% (84)	1.4% (5)	0.0% (0)
11-15 years	230	46	72.2% (166)	1.7% (4)	24% (56)	1.3% (3)	0.4% (1)
unknown	88	17.6	68.2% (60)	4.5% (4)	22% (19)	5.7% (5)	0.0% (0)
Provider of surgery							
nurse	0	0	0.0% (0)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
physician	7	1.4	100.0% (7)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
surgeon	1204	240.8	75.5% (909)	3.3% (40)	20% (238)	1.4% (17)	0.0% (0)
pediatric surgeon	2	0.4	0.0% (0)	0.0% (0)	100% (2)	0.0% (0)	0.0% (0)
other	4	0.8	50.0% (2)	0.0% (0)	0% (0)	50.0% (2)	0.0% (0)
unknown	38	7.6	94.7% (36)	0.0% (0)	0% (0)	0.0% (0)	5.3% (2)
Provider of anesthesia							
anesthesiologist	155	31	100.0% (155)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
anesthetist	1058	211.6	75.1% (795)	2.0% (21)	22% (238)	0.4% (4)	0.0% (0)
nurse	1	0.2	100.0% (1)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
clinical officer	0	0	0.0% (0)	0.0% (0)	0% (0)	0.0% (0)	0.0% (0)
other	63	12.6	46.0% (29)	30.2% (19)	0% (0)	23.8% (15)	0.0% (0)
Outcome of Surgery							
alive	631	126.2	54.2 % (342)	5.4% (34)	38% (239)	2.5% (16)	0.0% (0)
death	2	0.4	50.0% (1)	0.0% (0)	50% (1)	0.0% (0)	0.0% (0)
unknown	275	55	97.1% (267)	2.2% (6)	0% (0)	0.7% (2)	0.0% (0)

The Maroodi Jeex region performed 76% (954) of the pediatric surgeries in Somaliland. Out of the 954 pediatric surgeries, 531 were male and 412 were female. In the region, the hospitals completed surgeries on over 70% of children in each age range. The surgeons in the region performed 75.5% (909) of surgeries performed by surgeons in the country. One-hundred percent of all anesthesiologists attended surgeries occurred in Maroodi Jeex. The only nurse providing anesthesia occurred in the region. Only one out of two deaths occurred in Maroodi Jeex.

The Toghdeer region performed 3.2% (40) of pediatric surgeries. Most of those surgeries were completed on male children (n=28) in the one to five-year range (n=15). Only surgeons performed the surgeries and anesthetist provided anesthesia. Of the 40 surgeries in the region, 34 survived and 6 had an unknown outcome.

The Awdal region performed 19% (240) of all surgeries in the country. Of the 240 surgeries completed 238 were performed by a surgeon. This was the only region that had a pediatric surgeon perform surgery. All surgeries were attended by an anesthetist (n=238). There was only one death out of the 240 surgeries performed.

The Sanaag region performed 0.2% (2) of surgeries both of which were male children.

Hospital Region by Bellwether Capability

The fifteen hospitals were categorized by their ability to complete the bellwether procedures (Table 4.5).

Table 4.5.

Characteristics of Bellwether Capable Hospitals

Categories	Total (n)	Mean	Bellwethers (3/3) %(n)	BWs fracture + C-section %(n)	BWs fracture + laparotomy %(n)	BWs C-section + laparotomy %(n)	Bellwethers (1/3) %(n)	Bellwethers (0) %(n)
Number of hospitals	15.0	2.50	33.3% (5.0)	- -	6.7% (1.0)	40.0% (6.0)	6.7% (1.0)	13.3% (2.0)
Type of Hospital								
public/government	8.0	1.33	37.5% (3.0)	- -	0.0% (0.0)	37.5% (3.0)	12.5% (1.0)	12.5% (1.0)
private	6.0	1.00	33.3% (22)	- -	16.7% (1.0)	33.3% (2.0)	0.0% (0.0)	16.7% (1.0)
NGO/charity	1.0	0.17	0.0% (0.0)	- -	0.0% (0.0)	100.0% (1.0)	0.0% (0.0)	0.0% (0.0)
Surgical Delivery	0.0	0.00	0.0% (0.0)	- -	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)
Average patients admitted per month	1301.8	216.97	39.3% (512.0)	- -	18.4% (240.0)	21.1% (274.8)	13.8% (180.0)	7.3% (95.0)
Average pediatric patients admitted per month	232.9	38.81	35.5% (82.8)	- -	3.4% (8.0)	21.3% (49.6)	23.6% (55.0)	16.1% (37.5)
Average number of operations per month	423.5	70.58	29.3% (124.0)	- -	47.2% (200.0)	11.1% (47.0)	10.6% (45.0)	1.8% (7.5)
Average number of pediatric operations per month	21.9	3.65	43.4% (9.5)	- -	36.5% (8.0)	15.5% (3.4)	0.0% (0.0)	4.6% (1.0)
Personnel								
Average number of surgeons	14.5	2.42	22.0% (3.2)	- -	55.0% (8.0)	12.6% (1.8)	6.9% (1.0)	3.4% (0.5)
Average number of pediatric surgeons	0.2	0.03	0.0% (0.0)	- -	0.0% (0.0)	100.0% (0.2)	0.0% (0.0)	0.0% (0.0)
Average number of anesthesiologist	1.4	0.23	28.6% (0.4)	- -	71.4% (1.0)	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)

(Continued)

Categories	Total (n)	Mean	Bellwethers (3/3) %(n)		BWs fracture + C-section %(n)		BWs fracture + laparotomy %(n)		BWs C-section + laparotomy %(n)		Bellwethers (1/3) %(n)		Bellwethers (0/3) %(n)	
Average number of pediatric anesthesiologists	0.0	0.00	0.0%	(0.0)	-	-	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
Average number of anesthetist	11.4	1.90	38.6%	(4.4)	-	-	26.3%	(3.0)	21.9%	(2.5)	8.8%	(1.0)	4.4%	(0.5)
Average number of obstetricians	2.4	0.40	58.3%	(1.4)	-	-	0.0%	(0.0)	41.7%	(1.0)	0.0%	(0.0)	0.0%	(0.0)
Average number of nurses	117.8	19.64	46.7%	(55.0)	-	-	11.9%	(14.0)	20.7%	(24.3)	9.3%	(11.0)	11.5%	(13.5)
Infrastructure														
electricity availability (%)														
76-99	3.0	0.50	33.3%	(1.0)	-	-	0.0%	(0.0)	33.3%	(1.0)	33.3%	(1.0)	0.0%	(0.0)
100	12.0	2.00	33.3%	(4.0)	-	-	8.3%	(1.0)	41.7%	(5.0)	0.0%	(0.0)	16.7%	(2.0)
reliance on generator (%)														
0	2.0	0.33	0.0%	(0.0)	-	-	0.0%	(0.0)	50.0%	(1.0)	0.0%	(0.0)	50.0%	(1.0)
1-25	11.0	1.83	36.4%	(4.0)	-	-	0.0%	(0.0)	45.5%	(5.0)	9.1%	(1.0)	9.1%	(1.0)
100	1.0	0.17	0.0%	(0.0)	-	-	100.0%	(1.0)	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
water availability (100%)	15.0	2.50	33.3%	(5.0)	-	-	6.7%	(1.0)	40.0%	(6.0)	6.7%	(1.0)	13.3%	(2.0)
internet availability (%)														
76-99	13.0	2.17	38.5%	(5.0)	-	-	0.0%	(0.0)	46.2%	(6.0)	7.7%	(1.0)	7.7%	(1.0)
100	2.0	0.33	0.0%	(0.0)	-	-	50.0%	(1.0)	0.0%	(0.0)	0.0%	(0.0)	50.0%	(1.0)
phone availability (%)														
76-99	2.0	0.33	0.0%	(0.0)	-	-	0.0%	(0.0)	50.0%	(1.0)	50.0%	(1.0)	0.0%	(0.0)
100	13.0	2.17	38.5%	(5.0)	-	-	7.7%	(1.0)	38.5%	(5.0)	00%	(0.0)	15.4%	(2.0)
oxygen availability (%)														
51-75	2.0	0.33	0.0%	(0.0)	-	-	0.0%	(0.0)	100.0%	(2.0)	0.0%	(0.0)	0.0%	(0.0)
76-99	9.0	1.50	44.4%	(4.0)	-	-	0.0%	(0.0)	33.3%	(3.0)	11.1%	(1.0)	11.1%	(1.0)

(Continued)

Categories	Total (n)	Mean	Bellwethers (3/3) %(n)		BWs fracture + C-section %(n)		BWs fracture + laparotomy %(n)		BWs C-section + laparotomy %(n)		Bellwethers (1/3) %(n)		Bellwethers (0/3) %(n)	
Average number of hospital beds	434.5	72.42	43.7%	(190.0)	-	-	14.3%	(62.0)	24.7%	(107.5)	8.7%	(38.0)	8.5%	(37.0)
Average number of pediatric hospital beds	68.3	11.38	31.9%	(21.8)	-	-	0.0%	(0.0)	23.4%	(16.0)	8.8%	(6.0)	35.9%	(24.5)
Average number of functional operating rooms	13.9	2.31	23.1%	(3.2)	-	-	36.1%	(5.0)	15.6%	(2.2)	14.4%	(2.0)	10.8%	(1.5)
Average number of functional anesthesia machines	9.1	1.52	28.6%	(2.6)	-	-	22.0%	(2.0)	27.5%	(2.5)	11.0%	(1.0)	11.0%	(1.0)
Average number of functional ventilators	3.7	0.62	5.4%	(0.2)	-	-	81.1%	(3.0)	13.5%	(0.5)	0.0%	(0.0)	0.0%	(0.0)

All Three Bellwethers

There were five hospitals that could complete all three bellwether procedures (C-section, laparotomy, and fracture repair). Three were public hospitals and two were private hospitals. Two were second level hospitals and three were third level hospitals. Of all patients admitted per month 39.3% (512) were admitted and 35.5% (83) of pediatric patients were admitted. The hospitals completed 29.3% (124) operations and 44.3% (9.5) pediatric operations per month. There were 22% (3.2) of all surgeons and 46.7% (55) nurses working at these hospitals, on average. Most of these had access to electricity, water, phone, oxygen, and internet 76-99% of the time. There were 43.7% (190) of beds and 31.9% (21.8) of pediatric beds available in these hospitals. On average, 3.2 functional operating rooms, 2.6 anesthesia machines, and 0.2 ventilators were available for surgery.

Two Bellwethers

Hospitals were categorized by whether they could complete two out of the three procedures. No hospitals completed just fracture repair and C-sections.

Fracture and laparotomy. Only one hospitals completed just fracture repairs and laparotomies. It was a private third level hospital. It admitted 18.4% (240) patients and 3.4% (8) pediatric patients per month. It completed 47.2% (200) operations and 36.5 % (8) pediatric operations per month. It had 8 surgeons, 1 anesthesiologist, 3 anesthetists, and 14 nurses. All utilities and oxygen were available 100% of the time. It had 62 hospitals beds and no pediatric hospital beds. It had 5 functional operating rooms, 2 anesthesia machines, and 3 functional ventilators available for surgery.

C-section and laparotomy. There were six hospitals that were able to complete C-sections and laparotomies. Three were public, two were private, and one was an NGO hospital. There were 21.1% (274.8) patients and 21.3% (49.6) pediatric patients admitted per month. They completed 11.1% (47) operations and 15.5% (3.4) pediatric operations per month. There is an average of 1.8 surgeons and the only pediatric surgeon in the country was in one of these hospitals. They have an average of 25.3 nurses and 1 obstetrician. All utilities and oxygen are available at least 50% of the time. There is 24.7% (107.5) beds and 23.4% (16) pediatric beds available, on average. There are 2.2 functional operating rooms, 2.5 anesthesia machines, and 0.5 functional ventilators available for surgery, on average.

Collapsed two bellwethers. The hospitals that could complete two bellwethers were collapsed into one group (Table 4.6). There were seven hospitals that could complete at least two. Three were private, three were public, and one was an NGO hospital. There were 39.5% (514.8) patients and 24.7% (57.6) pediatric patients admitted per month. Of the operations per month, 58.3% (247) general and 52.1% (11.4) pediatric operations were completed. The average number of surgeons available for surgery was 9.8 and pediatric surgeons 0.2. The average number of anesthesiologists available to administer anesthesia was 1 and anesthetist was 5.5. There was an average of 1 obstetrician and 38.3 nurses. The utilities were available at least 76% of the time. Oxygen is available at least 50% of the time. There was an average of 169.5 hospital beds and 16 pediatric beds. The was an average of 7.2 functional operating rooms, 4.5 anesthesia machines, and 3.5 ventilators available for surgery.

One Bellwether

There was only one hospital that completed one bellwether procedure. It was a public, second level hospitals. It admitted 13.8% (180) patients and 23.6% (55) pediatric patients per month. It completed 10.6% (45) operations per month. There was one surgeon, one anesthetist, and 11 nurses. The utilities and oxygen were available 76-99% of the time. There were 38 beds and 6 pediatric beds available. There were two functional operating rooms with one anesthesia machine and no ventilators.

No Bellwether

There were two hospitals that could not complete any bellwether procedures. One was a public and the other was a private hospital. They admitted 7.3% (95) patients and 16.1% (37.5) pediatric patients per month. They completed 1.8% (7.5) operations and 4.6% (1) pediatric operation per month. There were 0.5 surgeons, 0.5 anesthetists, and 13.5 nurses available for surgery, on average. The utilities and oxygen were available 76-99% of the time. There were 37 beds and 24.5 pediatric beds available. On average, there were 1.5 functional operating rooms with one anesthesia machine available for surgery.

Collapsed One and Zero Bellwethers

Hospitals that could complete one or none of the bellwethers were collapsed into one group (Table 4.6). The three hospitals admitted 21.1% (275) patients and 39.7% (92.5) pediatric patients per month. They conducted 12.4% (52.5) operations and 4.6% (1) pediatric operation per month. The personnel consisted of 10.3% of surgeons, 13.2% of anesthetists, and 20.8% of nurses in Somaliland. The utilities and oxygen are available at least 76% of the time. The hospitals had an average of 75 beds and 30.5

Table 4.6.

Collapsed Bellwethers Description

Categories	Total (n)	Mean	Bellwethers (3/3) % (n)		Bellwethers (2/3) % (n)		Bellwethers (0-1/3) % (n)	
Number of hospitals	15.0	5.00	33.3%	(5.0)	46.7%	(7.0)	20.0%	(3.0)
Type of Hospital								
public/government	8.0	2.67	37.5%	(3.0)	37.5%	(3.0)	25.0%	(2.0)
private	6.0	2.00	33.3%	(2.0)	50.0%	(3.0)	16.7%	(1.0)
NGO/charity	1.0	0.33	0.0%	(0.0)	100.0%	(1.0)	0.0%	(0.0)
faith-based	0.0	0.00	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
Surgical Delivery								
Average patients admitted per month	1301.8	433.93	39.3%	(512.0)	39.5%	(514.8)	21.1%	(275.0)
Average pediatric patients admitted per month	232.9	77.62	35.5%	(82.8)	24.7%	(57.6)	39.7%	(92.5)
Average number of operations per month	423.5	141.17	29.3%	(124.0)	58.3%	(247.0)	12.4%	(52.5)
Average number of pediatric operations per month	21.9	7.30	43.4%	(9.5)	52.1%	(11.4)	4.6%	(1.0)
Personnel								
Average number of surgeons	14.5	4.84	22.0%	(3.2)	67.7%	(9.8)	10.3%	(1.5)
Average number of pediatric surgeons	0.2	0.06	0.0%	(0.0)	100.0%	(0.2)	0.0%	(0.0)
Average number of anesthesiologist	1.4	0.47	28.6%	(0.4)	71.4%	(1.0)	0.0%	(0.0)
Average number of pediatric anesthesiologists	0.0	0.00	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
Average number of anesthetist	11.4	3.80	38.6%	(4.4)	48.2%	(5.5)	13.2%	(1.5)
Average number of obstetricians	2.4	0.80	58.3%	(1.4)	41.7%	(1.0)	0.0%	(0.0)
Average number of nurses	117.8	39.28	46.7%	(55.0)	32.5%	(38.3)	20.8%	(24.5)
Infrastructure electricity availability (%)								
76-99	3.0	1.00	33.3%	(1.0)	33.3%	(1.0)	33.3%	(1.0)
100	12.0	4.00	33.3%	(4.0)	50.0%	(6.0)	16.7%	(2.0)
reliance on generator (%)								
0	2.0	0.67	0.0%	(0.0)	50.0%	(1.0)	50.0%	(1.0)
1-25	11.0	3.67	36.4%	(4.0)	45.5%	(5.0)	18.2%	(2.0)
100	1.0	0.33	0.0%	(0.0)	100.0%	(1.0)	0.0%	(0.0)

(Continued)

Categories	Total (n)	Mean	Bellwethers (3/3) % (n)		Bellwethers (2/3) % (n)		Bellwethers (0- 1/3) % (n)	
water availability (100%)	15.0	5.00	33.3%	(5.0)	46.7%	(7.0)	20.0%	(3.0)
internet availability (%)								
76-99	13.0	4.33	38.5%	(5.0)	46.2%	(6.0)	15.4%	(2.0)
100	2.0	0.67	0.0%	(0.0)	50.0%	(1.0)	50.0%	(1.0)
phone availability (%)								
76-99	2.0	0.67	0.0%	(0.0)	50.0%	(1.0)	50.0%	(1.0)
100	13.0	4.33	38.5%	(5.0)	46.2%	(6.0)	15.4%	(2.0)
oxygen availability (%)								
51-75	2.0	0.67	0.0%	(0.0)	100.0%	(2.0)	0.0%	(0.0)
76-99	9.0	3.00	44.4%	(4.0)	33.3%	(3.0)	22.2%	(2.0)
100	4.0	1.33	25.0%	(1.0)	50.0%	(2.0)	25.0%	(1.0)
Average number of hospital beds	434.5	144.83	43.7%	(190.0)	39.0%	(169.5)	17.3%	(75.0)
Average number of pediatric hospital beds	68.3	22.77	31.9%	(21.8)	23.4%	(16.0)	44.7%	(30.5)
Average number of functional operating rooms	13.9	4.62	23.1%	(3.2)	51.7%	(7.2)	25.2%	(3.5)
Average number of functional anesthesia machines	9.1	3.03	28.6%	(2.6)	49.5%	(4.5)	22.0%	(2.0)
Average number of functional ventilators	3.7	1.23	5.4%	(0.2)	94.6%	(3.5)	0.0%	(0.0)

pediatric hospitals beds. They had 3.5 functional operating rooms and 2 anesthesia machines available for surgery.

Pediatric Surgery by Bellwether Capability

The pediatric surgeries were categorized by the bellwether capability of the hospital in which the surgery was conducted (Table 4.7).

All Bellwethers

Of the pediatric surgeries completed 29.3% (295) surgeries were completed in an all bellwether capable hospital. There were 183 males and 110 females that had surgery. Of the children that had surgery in Somaliland, 22.5% of children less than a year, 30.3% of children 1-5 years, 32.5% of children 6-10 years, and 30.7% of children 11-14 years had surgery at these hospitals. Of the surgeries, 30% were performed by surgeon and the only two surgeries performed by a pediatric surgeon were completed at these hospitals. They completed over 50% of the surgeries for abdominal, bone, abscess, mass, bacterial infection, other, and unknown surgeries. There was only one death that occurred in surgery.

Two Bellwethers

Pediatric surgeries were categorized by their ability to complete two of the three bellwether procedures. No hospital completed fracture and C-section.

Fracture and Laparotomy. These hospitals completed 34.1% of the pediatric surgeries. They completed surgery on 197 males and 147 females. Of the children that had surgery in Somaliland, 7% of children less than a year, 34.3% of children 1-5 years,

Table 4.7.

Pediatric surgeries by bellwether capabilities

Categories	Total (n)	Mean	Bellwethers (3/3) %(n)	BWs fracture+ C-section %(n)	BWs fracture+ laparotomy %(n)	BWs C-section+ laparotomy %(n)	Bellwethers (1/3) %(n)	Bellwethers (0) %(n)
Number of surgeries	1007	167.83	29.3% (295.0)	- -	34.1% (343.0)	34.4% (346.0)	1.1% (11.0)	1.2% (12.0)
unknown	243	40.50	- -	- -	- -	- -	- -	- -
Gender								
male	587	97.83	31.2% (183.0)	- -	33.6% (197.0)	33.6% (197.0)	0.7% (4.0)	1.0% (6.0)
female	415	69.17	26.5% (110.0)	- -	35.4% (147.0)	34.9% (145.0)	1.7% (7.0)	1.4% (6.0)
unknown	6	1.00	33.3% (2.0)	- -	0.0% (0.0)	66.7% (4.0)	0.0% (0.0)	0.0% (0.0)
Age								
<1	213	35.50	22.5% (48.0)	- -	7.0% (15.0)	70.4% (150.0)	0.0% (0.0)	0.0% (0.0)
1-5 years	271	45.17	30.3% (82.0)	- -	34.3% (93.0)	33.9% (92.0)	1.5% (4.0)	0.0% (0.0)
6-10 years	283	47.17	32.5% (92.0)	- -	46.3% (131.0)	19.4% (55.0)	1.4% (4.0)	0.4% (1.0)
11-15 years	179	29.83	30.7% (55.0)	- -	46.4% (83.0)	19.6% (35.0)	1.1% (2.0)	2.2% (4.0)
Unknown	61	10.17	29.5% (18.0)		34.4% (21.0)	23.0% (14.0)	1.6% (1.0)	11.5% (7.0)
Provider of surgery								
nurse	0	0.00	0.0% (0.0)	- -	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)
physician	2	0.33	0.0% (0.0)	- -	0.0% (0.0)	100.0% (2.0)	0.0% (0.0)	0.0% (0.0)
surgeon	763	127.17	30.0% (299.0)	- -	28.0% (214)	40.5% (309.0)	1.4% (11.0)	0.0% (0.0)
pediatric surgeon	2	0.33	100.0% (2.0)	- -	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)	0.0% (0.0)
other	2	0.33	0.0% (0.0)	- -	0.0% (0.0)	100.0% (2.0)	0.0% (0.0)	0.0% (0.0)
unknown	238	39.67	26.9% (64.0)	- -	54.2% (129.0)	13.9% (33.0)	0.0% (0.0)	5.0% (12.0)

(Continued)

Categories	Total (n)	Mean	Bellwethers (3/3) %(n)		BWs fracture+ C-section %(n)		BWs fracture+ laparotomy %(n)		BWs C-section+ laparotomy %(n)		Bellwethers (1/3) %(n)		Bellwethers (0) %(n)	
Surgical Condition														
Congenital Anomalies	305	50.83	15.4%	(47.0)	-	-	6.2%	(19.0)	78.4%	(239.0)	0.0%	(0.0)	0.0%	(0.0)
Tonsillitis	99	16.50	3.0%	(3.0)	-	-	97.0%	(96.0)	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
Trauma/wound/snake	145	24.17	33.8%	(49.0)	-	-	44.1%	(64.0)	15.2%	(22.0)	6.9%	(10.0)	0.0%	(0.0)
Eye	114	19.00	0.0%	(0.0)	-	-	100.0%	(114.0)	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)
Abdominal	34	5.67	76.5%	(26.0)	-	-	8.8%	(3.0)	11.8%	(4.0)	2.9%	(1.0)	0.0%	(0.0)
Bone	83	13.83	72.3%	(60.0)	-	-	19.3%	(16.0)	3.6%	(3.0)	0.0%	(0.0)	4.8%	(4.0)
Abscess	40	6.67	62.5%	(25.0)	-	-	5.0%	(2.0)	32.5%	(13.0)	0.0%	(0.0)	0.0%	(0.0)
Contracture	38	6.33	5.3%	(2.0)	-	-	0.0%	(0.0)	94.7%	(36.0)	0.0%	(0.0)	0.0%	(0.0)
Hematoma	11	1.83	9.1%	(1.0)	-	-	9.1%	(1.0)	9.1%	(1.0)	0.0%	(0.0)	72.7%	(8.0)
Mass	40	6.67	55.0%	(22.0)	-	-	15.0%	(6.0)	30.0%	(12.0)	0.0%	(0.0)	0.0%	(0.0)
Other	62	10.33	59.7%	(37.0)	-	-	25.8%	(16.0)	14.5%	(9.0)	0.0%	(0.0)	0.0%	(0.0)
Bacterial Infection	24	4.00	70.8%	(17.0)			20.8%	(5.0)	8.3%	(2.0)	0.0%	(0.0)	0.0%	(0.0)
Unknown	12	2.00	50.0%	(6.0)	-	-	8.3%	(1.0)	41.7%	(5.0)	0.0%	(0.0)	0.0%	(0.0)
Outcome of Surgery														
alive	494	82.33	21.7%	(107.0)	-	-	43.3%	(214.0)	32.8%	(162.0)	2.2%	(11.0)	0.0%	(0.0)
death	2	0.33	50.0%	(1.0)	-	-	0.0%	(0.0)	50.0%	(1.0)	0.0%	(0.0)	0.0%	(0.0)
unknown	512	85.33	36.7%	(188.0)	-	-	25.2%	(129.0)	35.7%	(183.0)	0.0%	(0.0)	2.3%	(12.0)

46.3% of children 6-10 years, and 46.4% of children 11-14 years had surgery at these hospitals. Twenty-eight percent of pediatric surgeries were performed by surgeons in these hospitals. They completed 97% of all tonsillitis surgeries and 100% of all eye surgeries which include glaucoma and cataract surgeries. There were no deaths recorded at these hospitals.

C-section and Laparotomy. These hospitals completed 34.4% (346) of the pediatric surgeries. Of the surgeries, 197 were male and 145 were female. Of surgery on children less than 1 year of age, 70.4% of those surgeries were completed in these hospitals. Of the surgeries, 40.5% were completed by surgeons in these hospitals. They completed 94.7% of all contracture surgeries and 78.4% of all congenital anomaly surgeries. There was only one death reported at this hospital.

Collapsed two bellwethers. The surgeries that were completed in a two bellwether hospital were collapsed into one category (Table 4.8). There were 68.4% of pediatric surgeries completed in these hospitals. Of the pediatric patients that received surgery, 394 were male and 292 were female. Surgery was performed on over 50% of each age of pediatric patients. Physicians completed two of the surgeries and surgeons performed 523 surgeries. Over 50% of congenital anomaly, tonsillitis, trauma/wound/snake, eye, contracture, and unknown surgeries were completed in these hospitals. There was only one recorded death between these hospitals.

One Bellwether

There were only 11 pediatric surgeries completed at this hospital. Four were male and seven were female patients. No surgery was performed on children less than one year

of age. All 11 surgeries were performed by a surgeon. Ten were trauma/wound/snake surgeries and only one was abdominal surgery. There were no deaths reported at this hospital.

No Bellwethers

There were 12 pediatric surgeries completed at these hospitals. Half were male and half were female patients and were all above 6 years of age. The surgery provider for each surgery was unknown. Four were abdominal surgery and eight were hematoma surgery. There were no recorded deaths at these hospitals.

Collapsed One and Zero Bellwethers

The pediatric surgeries that were conducted in hospitals that could complete one or no bellwethers were collapsed into one category (Table 4.8). There were 23 pediatric surgeries completed in these hospitals. There were 10 male and 13 female pediatric patient. All pediatric patients were one year or older. Eleven of the surgeries were completed by a surgeon. One surgery was abdominal, 4 were related to bone injuries, and 8 were hematoma surgeries. There were no deaths reported at these hospitals.

Association between Bellwethers and Pediatric Characteristics

A chi square test was implemented to identify any association between a hospitals ability to complete the bellwethers and the pediatric surgery completed in those hospitals (Table 4.8). The evidence suggests an association between the pediatric variables (gender, age, provider of surgery, surgical condition, and outcome of surgery) and the hospitals completion of the bellwethers, $p<.05$ (Table 4.8).

Table 4.8.

Pediatric surgeries by collapsed bellwether procedures with p-values.

Categories	Total (n)	Mean	Bellwethers (3/3) % (n)		Bellwethers (2/3) % (n)		Bellwethers (0-1/3) % (n)		P-Value
Number of surgeries	1007	335.67	29.3%	(295.0)	68.4%	(689.0)	2.3%	(23.0)	
unknown	243	-	-	-	-	-	-	-	-
Gender									
male	587	195.67	31.2%	(183.0)	67.1%	(394.0)	1.7%	(10.0)	
female	415	138.33	26.5%	(110.0)	70.4%	(292.0)	3.1%	(13.0)	0.0003
unknown	6	2.00	33.3%	(2.0)	66.7%	(4.0)	0.0%	(0.0)	
Age									
<1	213	71.00	22.5%	(48.0)	77.5%	(165.0)	0.0%	(0.0)	
1-5 years	271	90.33	30.3%	(82.0)	68.3%	(185.0)	1.5%	(4.0)	0.0092
6-10 years	283	94.33	32.5%	(92.0)	65.7%	(186.0)	1.8%	(5.0)	
11-15 years	179	59.67	30.7%	(55.0)	65.9%	(118.0)	3.4%	(6.0)	
unknown	61	20.33	29.5%	(18.0)	57.4%	(35.0)	13.1%	(8.0)	
Provider of surgery									
nurse	0	0.00	0.0%	(0.0)	0.0%	(0.0)	0.0%	(0.0)	
physician	2	0.67	0.0%	(0.0)	100.0%	(2.0)	0.0%	(0.0)	
surgeon	763	254.33	30.0%	(229.0)	68.5%	(523.0)	1.4%	(11.0)	0.02
pediatric surgeon	2	0.67	100.0%	(2.0)	0.0%	(0.0)	0.0%	(0.0)	
other	2	0.67	0.0%	(0.0)	100.0%	(2.0)	0.0%	(0.0)	
unknown	238	79.33	26.9%	(64.0)	68.1%	(162.0)	5.0%	(12.0)	
Surgical Condition									
Congenital Anomalies	305	101.67	15.4%	(47.0)	84.6%	(258.0)	0.0%	(0.0)	
Tonsillitis	99	33.00	3.0%	(3.0)	97.0%	(96.0)	0.0%	(0.0)	
Trauma/wound/snake	145	48.33	33.8%	(49.0)	59.3%	(86.0)	6.9%	(10.0)	
Eye	114	38.00	0.0%	(0.0)	100.0%	(114.0)	0.0%	(0.0)	
Abdominal	34	11.33	76.5%	(26.0)	20.6%	(7.0)	2.9%	(1.0)	
Bone	83	27.67	72.3%	(60.0)	22.9%	(19.0)	4.8%	(4.0)	
Abscess	40	13.33	62.5%	(25.0)	37.5%	(15.0)	0.0%	(0.0)	<.0001
Contracture	38	12.67	5.3%	(2.0)	94.7%	(36.0)	0.0%	(0.0)	
Hematoma	11	3.67	9.1%	(1.0)	18.2%	(2.0)	72.7%	(8.0)	
Mass	40	13.33	55.0%	(22.0)	45.0%	(18.0)	0.0%	(0.0)	
Other	62	20.67	59.7%	(37.0)	40.3%	(25.0)	0.0%	(0.0)	
Bacterial Infection	24	8.00	70.8%	(17.0)	29.2%	(7.0)	0.0%	(0.0)	
Unknown	12	4.00	50.0%	(6.0)	50.0%	(6.0)	0.0%	(0.0)	
Outcome of Surgery									
alive	494	164.67	21.7%	(107.0)	76.1%	(376.0)	2.2%	(11.0)	
death	2	0.67	50.0%	(1.0)	50.0%	(1.0)	0.0%	(0.0)	<.0001
unknown	512	170.67	36.7%	(188.0)	60.9%	(312.0)	2.3%	(12.0)	

Hospital Characteristics by Emergent and Elective Surgery

To identify the hospitals surgical capacity, the type of surgery was categorized by hospital characteristics (Table 4.9).

Type of Hospital

The public hospitals completed 68% (170) emergent surgeries and 32% (80) elective surgeries. The private hospitals completed 25.39% (115) emergent surgeries and 74.61% (338) elective surgeries. The only NGO hospital completed 48.01% (145) emergent surgeries and 51.99% (157) elective surgeries.

Surgical Delivery

Of the patients admitted per month, 55.99% (404.8) were emergency cases and 44.01% (318.13) were elective cases. Of the pediatric patients admitted per month, 61.96% (46.81) were emergent and 38.04% (28.74) were elective cases. There were 49.33% (122.49) emergent operations and 50.67% (125.81) elective operations per month. The pediatric operations per month consisted of 51.63% (8.25) emergent surgeries and 48.37% (7.73) elective surgeries.

Table 4.9

Hospital characteristics by type of surgery completed (elective or emergent).

Categories	Total (n)	Mean	Emergent %(n)		Elective % (n)	
Type of Hospital						
public/government	250.00	125.00	68.00%	(170.00)	32.00%	(80.00)
private	453.00	226.50	25.39%	(115.00)	74.61%	(338.00)
NGO/charity	302.00	151.00	48.01%	(145.00)	51.99%	(157.00)
faith-based	-	-	-	-	-	-
Surgical Delivery						
Average patients admitted per month	722.93	361.47	55.99%	(404.80)	44.01%	(318.13)
Average pediatric patients admitted per month	75.55	37.78	61.96%	(46.81)	38.04%	(28.74)
Average number of operations per month	248.30	124.15	49.33%	(122.49)	50.67%	(125.81)
Average number of pediatric operations per month	15.98	7.99	51.63%	(8.25)	48.37%	(7.73)
Personnel						
Average number of surgeons	8.45	4.23	46.63%	(3.94)	53.37%	(4.51)
Average number of pediatric surgeons	0.61	0.31	55.74%	(0.34)	44.26%	(0.27)
Average number of anesthesiologist	0.65	0.33	36.92%	(0.24)	63.08%	(0.41)
Average number of pediatric anesthesiologists	0.00	0.00	0.00%	(0.00)	0.00%	(0.00)
Average number of anesthetist	9.64	4.82	55.71%	(5.37)	44.29%	(4.27)
Average number of obstetricians	2.52	1.26	64.29%	(1.62)	35.71%	(0.90)
Average number of nurses	91.95	45.98	61.31%	(56.37)	38.69%	(35.58)

(Continued)

Categories	Total (n)	Mean	Emergent %(n)		Elective % (n)	
Infrastructure						
electricity availability (%)						
76-99	15.00	7.50	80.00%	(12.00)	20.00%	(3.00)
100	990.00	495.00	42.22%	(418.00)	57.78%	(572.00)
reliance on generator (%)						
0	14.00	7.00	78.57%	(11.00)	21.43%	(3.00)
1-25	468.00	234.00	41.45%	(194.00)	58.55%	(274.00)
100	338.00	169.00	30.18%	(102.00)	69.82%	(236.00)
water availability (100%)	1005.00	502.50	42.79%	(430.00)	57.21%	(575.00)
internet availability (%)						
76-99	666.00	333.00	49.10%	(327.00)	50.90%	(339.00)
100	339.00	169.50	30.38%	(103.00)	69.62%	(236.00)
phone availability (%)						
76-99	49.00	24.50	71.43%	(35.00)	28.57%	(14.00)
100	956.00	478.00	41.32%	(395.00)	58.68%	(561.00)
oxygen availability (%)						
51-75	41.00	20.50	65.85%	(27.00)	34.15%	(14.00)
76-99	138.00	69.00	23.19%	(32.00)	76.81%	(106.00)
100	826.00	413.00	44.92%	(371.00)	55.08%	(455.00)
Average number of hospital beds	324.10	162.05	61.89%	(200.57)	38.11%	(123.53)
Average number of pediatric hospital beds	31.17	15.59	58.33%	(18.18)	41.67%	(12.99)
Average number of functional operating rooms	7.93	3.97	49.56%	(3.93)	50.44%	(4.00)
Average number of functional anesthesia machines	6.28	3.14	51.11%	(3.21)	48.89%	(3.07)
Average number of functional ventilators	4.17	2.09	48.20%	(2.01)	51.80%	(2.16)

Personnel

On average, surgeons were available to complete 46.3% (3.94) of emergency surgeries and 53.37% (4.51) of elective surgeries in each hospital. The average number of pediatric surgeons available for emergent surgery was 0.34 and for elective surgery was 0.27. An anesthesiologist was available for 0.24 emergent surgeries and 0.41 elective surgeries, on average. There were 5.37 anesthetist available for emergent surgery and 4.27 available for elective surgery on average. There were 1.62 obstetricians available for emergent surgery and 0.9 for elective surgery. There were 56.37 nurses available for emergent surgery and 35.58 for elective surgery.

Infrastructure

Utilities were available for emergent and elective surgery over 76% of the time. Oxygen is available over 50% of the time for emergent and elective surgery. There were 200.57 beds and 18.18 pediatric beds available for emergent surgeries and 123.53 beds and 12.99 pediatric available for elective surgeries patients. There were 3.93 functional operating rooms, 3.21 functional anesthesia machines, and 2.01 functional ventilators available for emergent surgery. There were 4 functional operating rooms, 3.07 functional anesthesia machines, and 2.16 functional ventilators available for elective surgery.

Pediatric Surgeries by Emergent and Elective Surgery

Pediatric surgeries were categorized into elective and emergent surgeries (Table 4.10). There were 712 elective surgeries and 505 emergent surgeries in total.

Table 4.10

Pediatric surgeries by elective and emergent surgery

Categories	Total (n)	Mean	Emergent %(n)		Elective % (n)	
Number of surgeries performed	1217	608.50	41.5%	(505.00)	58.5%	(712.00)
Gender						
male	685	342.50	41.8%	(286.00)	58.2%	(399.00)
female	517	258.50	40.0%	(207.0)	60.0%	(310.00)
unknown	15	7.50	80.0%	(12.00)	20.0%	(3.00)
Age						
>1	246	123.00	43.1%	(106.00)	56.9%	(140.00)
1-5 years	309	154.50	40.5%	(125.00)	59.5%	(184.00)
6-10 years	349	174.50	39.0%	(136.00)	61.0%	(213.00)
11-15 years	224	112.00	43.8%	(98.00)	56.3%	(126.00)
unknown	89	44.50	44.9%	(40.00)	55.1%	(49.00)
Provider of surgery						
nurse	0	0.00	0.0%	(0.00)	0.0%	(0.00)
physician	2	1.00	100.0%	(2.00)	0.0%	(0.00)
surgeon	897	448.50	42.9%	(385.00)	57.1%	(512.00)
pediatric surgeon	2	1.00	0.0%	(0.00)	100.0%	(2.00)
other	2	1.00	50.0%	(1.00)	50.0%	(1.00)
unknown	314	157.00	37.3%	(117.00)	62.7%	(197.00)
Surgical Condition						
Congenital Anomalies	332	166.00	41.3%	(137.00)	58.7%	(195.00)
Tonsillitis	227	113.50	33.9%	(77.00)	66.1%	(150.00)
Trauma/wound/snake	143	71.50	45.5%	(65.00)	54.5%	(78.00)
Eye	113	56.50	29.2%	(33.00)	70.8%	(80.00)
Abdominal	44	22.00	50.0%	(22.00)	50.0%	(22.00)

(Continued)

Categories	Total (n)	Mean	Emergent %(n)		Elective % (n)	
Bone	82	41.00	53.7%	(44.00)	46.3%	(38.00)
Abscess	47	23.50	53.2%	(25.00)	46.8%	(22.00)
Contracture	38	19.00	36.8%	(14.00)	63.2%	(24.00)
Hematoma	19	9.50	57.9%	(11.00)	42.1%	(8.00)
Mass	38	19.00	52.6%	(20.00)	47.4%	(18.00)
Other	100	50.00	40.0%	(40.00)	60.0%	(60.00)
Bacterial Infection	24	12.00	50.0%	(12.00)	50.0%	(12.00)
Unknown	10	5.00	50.0%	(5.00)	50.0%	(5.00)
Provider of anesthesia						
anesthesiologist	65	32.50	23.1%	(15.00)	76.9%	(50.00)
anesthetist	797	398.50	43.7%	(348.00)	56.3%	(449.00)
nurse	1	0.50	100.0%	(1.00)	0.0%	(0.00)
clinical officer	0	0.00	0.0%	(0.00)	0.0%	(0.00)
other	34	17.00	70.6%	(24.00)	29.4%	(10.00)
unknown	320	160.00	36.6%	(117.00)	63.4%	(203.00)
Outcome of Surgery						
alive	621	310.50	38.8%	(241.00)	61.2%	(380.00)
death	2	1.00	50.0%	(1.00)	50.0%	(1.00)
unknown	274	137.00	52.6%	(144.00)	47.4%	(130.00)

Gender

There were 286 males that had emergent surgery and 399 that had elective surgery. There were 207 females that had emergent surgery and 310 that had elective surgery. There were 12 unknown emergent and 3 unknown elective surgeries

Age

Of children <1 year of age, 43.1% (106) had emergent surgery and 56.9% (140) had elective surgery. Of children 1-5 years of age, 40.5% (125) had emergent surgery and 59.5% (184) had elective surgery. Of children 6-10 years of age, 39% (136) had emergent surgery and 61% (213) had elective surgery. Of children 11-14 years of age, 43.8% (98) had emergent surgery and 56.3% (126) had elective surgery.

Surgical Provider

A physician completed 2 emergent surgeries and a surgeon completed 385 emergent surgeries and 512 elective surgeries. A pediatric surgeon completed only two elective surgeries. The other surgeries were completed by an unknown provider.

Surgical Condition

Pediatric patients were categorized into 13 different surgical conditions. There were 41.3% (137) emergent and 58.7% (195) elective congenital anomaly surgeries. There were 33.9% (77) emergent and 66.1% (150) elective tonsillitis surgeries. There were 45.5% (65) emergent and 54.5% (78) elective trauma/wound/snake surgeries. There were 29.2% (33) emergent and 70.8% (80) elective eye surgeries. There were 50% (22) emergent and 50% (22) elective abdominal surgeries. There were 53.7% (44) emergent and 46.3% (38) elective bone repair surgeries. There were 53.2% (25) emergent and 46.8 (22) elective abscess surgeries. There were 36.8% (14) emergent and 63.2% (24) elective contracture surgeries. There were 57.9% (11) emergent and 42.1% (8) elective hematoma surgeries. There were 52.6% (20) emergent and 47.4% (18) elective mass surgeries. There were 40% (40) emergent and 60% (60) elective other types of surgeries. There were 50% (12) emergent and 50% (12) elective bacterial infection surgeries. There were 50% (5) emergent and 50% (5) elective unknown surgeries.

Anesthesia Provider

An anesthesiologist attended 15 emergent and 50 elective surgeries. An anesthetist administered anesthesia at 348 emergent surgeries and 449 elective surgeries.

A nurse administered anesthesia at one emergent surgery. Other healthcare workers administered anesthesia at 24 emergent and 10 elective surgeries.

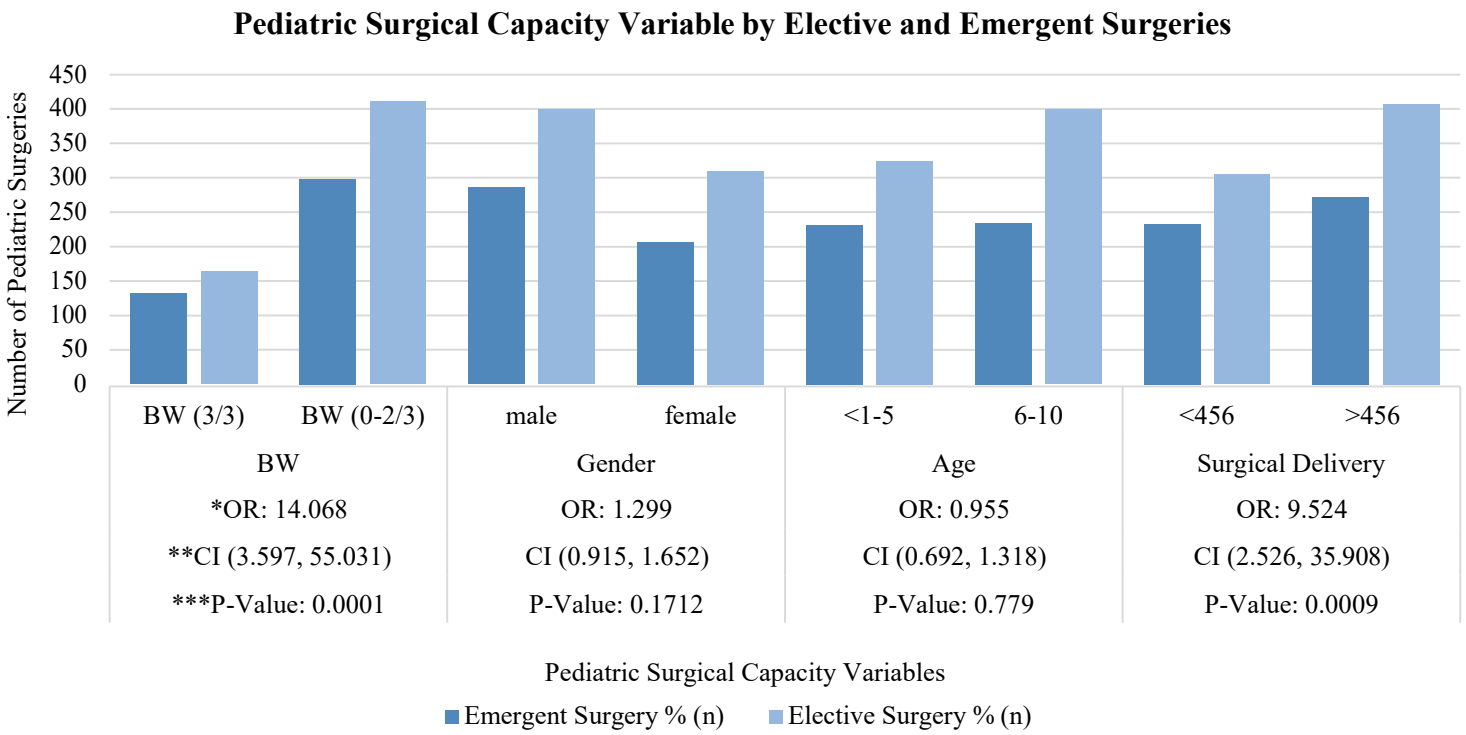
Outcome of Surgery

There was only one recorded death during emergent surgery and one during elective surgery.

Influence of Surgical Capacity on Elective and Emergent Surgery

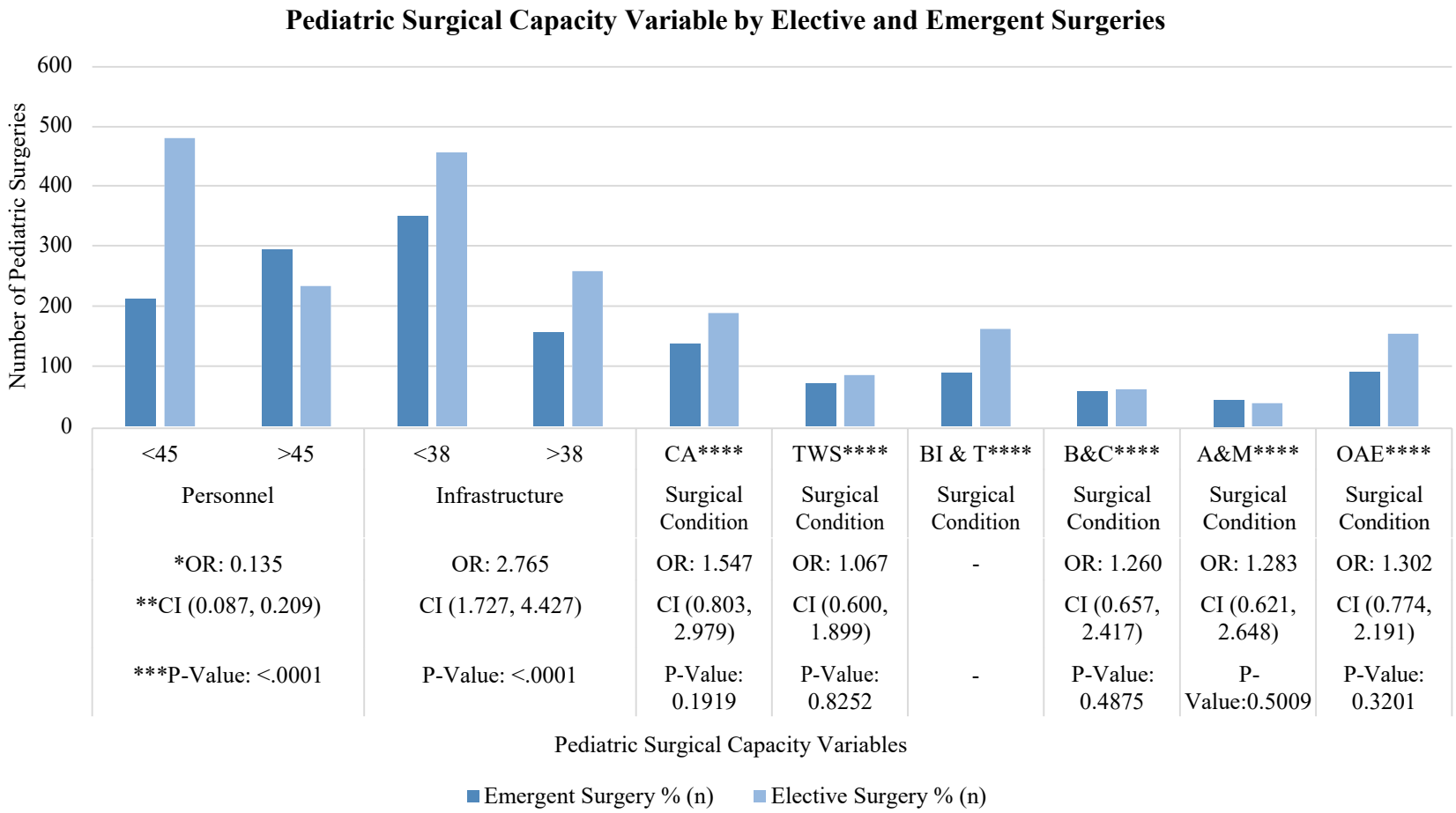
A multivariate regression was run to identify the effect surgical capacity variables had on whether a child receives elective or emergent surgery (Table 4.11). Surgical delivery is a combination of patients and pediatrics admitted per month and operations and pediatric operations per month. The variable personnel includes nurses, anesthetists, surgeons, and pediatric surgeons. The variable infrastructure includes functional generators, internet, hospital beds, oxygen, phone availability, and functional ventilator. These variables were created using a principal component analysis (PCA). The values were chosen by identifying the median of these newly created variables. For the personnel variable, the median and the 75^{th} percentile were equivalent. The value was still accepted because it had a significant p-value <.05 and adequately demonstrated the influence of personnel on elective and emergent surgery. The variables bellwether capability, gender, surgical delivery, infrastructure, and surgical conditions all had an odds ratio >1. The odds ratio for bellwethers was 14.068 and a 95% Confidence Interval (CI) at (3.597, 55.031), gender was 1.299 (0.915, 1.652), surgical delivery was 9.524 (2.526, 35.908), infrastructure was 2.765 (1.727, 4.427), and each surgical condition was >1. Pediatric age and personnel have an odds ratio <1. The odds ratio for age was 0.955 (0.692, 1.318) and personnel was 0.135 (0.087, 0.209).

Figure 4.1: Influence of surgical capacity variables on the completion of emergent and elective pediatric surgery



*OR: Odds Ratio created by a multivariate regression with all pediatric surgical capacity variables included in the equation.
**CI: 95% Confidence Interval for the Odds Ratio. ***P-Value: Significance is <.05.

(Continued)



*OR: Odds Ratio created by a multivariate regression with all pediatric surgical capacity variables included in the equation. **CI: 95% Confidence Interval for the Odds Ratio. ***P-Value: Significance is <.05. ****Abbreviations for surgical conditions: CA-Congenital Anomalies; TWS-Trauma/Wound/Snake; BI&T- Bacterial Infection & Tonsillitis; B&C- Bone and Contracture; A&M- Abscess & Mass; OAE – Other, Abdominal, Eyes.

Bellwether, surgical delivery, infrastructure, and personnel all had significant p-values <.05. The hospitals capable of completing all three current bellwethers are 14.068 times more likely to complete elective pediatric surgeries. The CI (3.597, 55.031) is large which indicates there is less confidence for the OR. However, the minimum CI is above 1 so despite the large range there is an effect on pediatric surgery if the bellwethers is completed in a hospital. The Somaliland hospitals that have an adult and pediatric admittance and operating rate >456 per month are 9.524 times more likely to complete elective pediatric surgery. Somaliland hospitals that have >45 surgical providers are 0.135 times likely to complete elective surgery. This means that elective surgeries will be delayed which can influence the future health outcomes of children. A hospital is 2.765 times more likely to complete pediatric elective surgery if infrastructure is >38.

CHAPTER FIVE

Discussion

Key Findings

Surgical capacity of hospitals does influence whether a child in Somaliland receives emergent and elective surgery. Adequate surgical delivery, personnel, and infrastructure are crucial to children receiving surgery. Currently, many surgical resources are allocated to emergent services which leave children who need elective surgery at risk for disability. Even in developed countries, emergent patients require more resources for treatment.[38] Of the surgical conditions, 92% of congenital anomalies are recorded in LMICs.[5] From the above results, 58.7% of congenital anomaly surgeries are elective which means more than half of Somaliland children born with a congenital anomaly are not receiving surgical care for their condition because of their surgical status. Investing in surgical delivery by accepting an additional pediatric patient or in infrastructure by adding an extra hospital bed would increase a child's chances of receiving elective surgery. However, to generate the largest impact, investing in all three areas would increase surgical care for children in Somaliland.

Interpretations

Pediatric surgical capacity is currently being studied to determine the minimum a hospital needs to serve its child population. The Lancet Commission on Global Surgery 2030 (LCoGS)[1] provided indicators for surgical capacity but not pediatric surgical capacity. Other studies have attempted to create ideal metrics for surgical capacity which

have become new tools to measure current pediatric surgical capacity. Okoye et al[33] utilized the PediPIPES tool to identify pediatric surgical capacity in sub-Saharan Africa. However, these tools are limited because they cannot accurately evaluate surgical outcome which is necessary in identifying true surgical capacity.[36] Also, it does not distinguish between elective and emergent surgery which is crucial to understanding how surgical capacity affects the completion of these surgeries.

Bellwether Procedures

The hospitals capable of completing all three current bellwethers are more likely to complete elective pediatric surgeries. The bellwether procedures are indicative of have adequate surgical capacity according the LCoGS.[1] O'Neill et al[2] explained that being able to complete the bellwether procedures meant the hospital was able to complete other surgeries like general, all obstetric, and orthopedic surgeries. Also, the procedures are an indicator that the hospital has adequate supplies, equipment, and personnel to complete the surgeries.[2] Despite O'Neill saying they are not a good indicator for pediatric surgery[2], it is evident that a hospital that can complete the bellwethers is more likely to complete elective pediatric surgery according to this study.

Surgical Delivery

The Somaliland hospitals that have a high rate of adult and pediatric admittance and operations more likely to complete elective pediatric surgery. Bickler et al[32] recognized the need for increased surgical delivery. Hospitals cannot accept more patients that are in need of elective surgeries because the high rate of emergency cases admitted in the hospital.[32] This idea is consistent with the findings that a higher rate of

overall admittance and operations demonstrates a greater ability to complete elective surgery.

Personnel

Somaliland hospitals that have a high rate of surgical providers are less likely to complete elective surgery. This means that elective surgeries will be delayed which can influence the future health outcomes of children. In LMICs most emergent surgeries are conducted by general practitioners.[39] Trauma, wound, and emergency surgeries are more likely to be treated than congenial anomaly surgeries[39] which can be categorized as elective surgeries. Congenital anomaly surgeries require specialized pediatric surgeons to operate which many LMICs do not have.[39,40] The addition of surgical personnel can complete higher rates of emergent surgeries which opens up spaces for elective patients to be treated by specialized surgeons.

Infrastructure

A hospital is more likely to complete pediatric elective surgery if infrastructure is increased. To increase the infrastructure of a hospital, additional generators, hospital beds, oxygen, ventilators, and access to the internet and phones must increase. Chao et al[41] identified necessary infrastructure for surgery in Ethiopia. Water, oxygen, and generators were essential to complete surgery in Ethiopia.[41] These finding are similar to the items reported in this study.

Implications

Somaliland hospitals can increase their surgical capacity in three areas to improve pediatric surgical care: surgical delivery, personnel, and infrastructure. If surgical

delivery and infrastructure are increased, elective pediatric surgery will increase which decrease the DALYs of children in Somaliland. If personnel is increased, more emergent surgeries will be completed which permits specialized surgeons to complete elective surgeries.

If pediatric surgical care is increased, the child mortality and morbidity rate from surgical conditions will decrease. The 2362 DALYs of Somaliland children due to delay in surgical service[5] will be decreased by increasing infrastructure, surgical delivery, and personnel. Also, investing in increased surgical care, is more cost-effective than allowing these conditions to go untreated.[42]

Limitations

There are limitations to this study. The hospital surveys were self-reported which allows inaccurate answers to be recorded because some hospitals had to report their best estimate. Questions that asked about average number of operations, admittance, or surgeries per month and average number of surgical providers might not be accurate in comparison to the actual values. The data collectors clarified the questions by asking "within the last month" to provide a time-frame to help the participants provide a more accurate estimation.

The bellwethers procedures were utilized as the definition of surgical capacity however there is not currently a pediatric bellwether. Some have determined that the bellwethers is not the best tool to determine pediatric surgical capacity.[2] There are current studies researching procedures to create a pediatric bellwether.[32] The bellwethers have been found as a good indicator for many emergent surgeries because they have the infrastructure and personnel to complete surgery.[2] Though pediatric surgery is specialized

there are surgeries that can be completed using techniques that are used on the bellwether procedures.[2] Despite being a poor indicator of pediatric surgery, the Somaliland hospitals that could complete two or more bellwethers recorded more elective and emergent surgeries than those that completed less than two bellwethers.

Recommendations

The data suggest that pediatric elective surgery can be increased by focusing on infrastructure, surgical delivery, and personnel in hospitals. Some recommendations to practically increase capacity:

- Identification of one suggested area of focus for each individual hospital will be beneficial to begin capacity building.
- Additional allocation of resources will provide hospitals the ability to increase elective surgeries for children which will decrease the likelihood of children becoming disabled due to lack of surgical service.

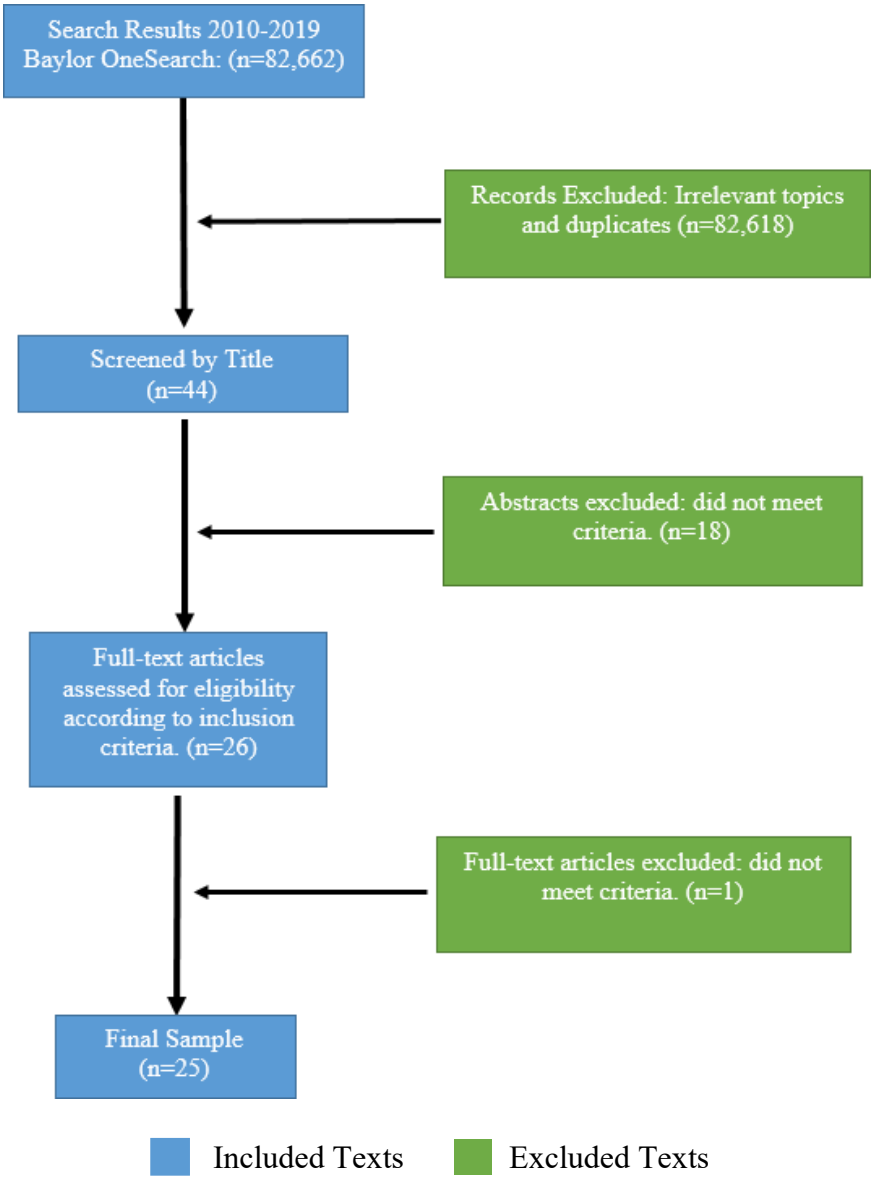
Conclusion

The children of LMICs are at risk due to the lack of pediatric surgical services in the country. The morbidity and mortality rate of children who do not receive adequate surgical care will increase. Choosing to invest in pediatric surgical care, can result in better outcomes for children in Somaliland.

APPENDICES

APPENDIX A

Figure A.1. PRISMA Flowchart: Articles utilized in the literature review.



APPENDIX B

Table B.1

Literature Review Table: A table of the articles used in the literature review.

Source	Definition of Surgical Capacity
Albutt K at al.	infrastructure, service delivery, workforce, information management, and financing through hospital walkthroughs, retrospective reviews of operative logbooks, and interviews with hospital directors and providers.
Aliu O et al.	Volunteer surgeons in participating in surgical capacity building through task shifting.
Anderson JE et al.	Infrastructure, workforce, working environment, finance, and service delivery.
Bhashyam AR et al.	Continuing medical education (CME) is an important part of capacity building in surgery
Bickler S.W. and Rode H.	Education and surgical skills training
Cairo S et al.	Personnel, Infrastructure, Procedure, Equipment, and Supplies (PIPES) tool
Cheelo M et al.	infrastructure, service delivery, workforce,
Deckelbaum DL et al.	This article focused on surgical workforce to improve surgical capacity.
Funk LM et al.	operating theatres, anesthesia and surgical equipment, pulse oximetry
Groen R et al.	personnel, infrastructure, procedures, equipment and supplies (PIPES).
Haglund M et al.	access to improved surgical, anesthetic, and monitoring equipment combined with the twinning of training camps,
Henry J et al.	personnel, infrastructure, procedures, equipment and supplies (PIPES).
Hughes C et al.	personnel, infrastructure, procedures, equipment and supplies (PIPES).
Khan FA et al.	inadequate access to medicines, equipment, supplies, devices, infrastructure, and suitably trained health care personnel
Kwon S et al.	Tool for Situational Analysis to Assess Emergency and Essential Surgical Care (TSAAEESC) [14]. This survey includes 256 data points for each facility, addressing four categories: infrastructure, procedures, equipment and supply list, and personnel.
Li Z et al.	surgical services, mainly caused by limited health human resources, logistics, medicine, infrastructure, equipment, and supplies

(Continued)

Source	Definition of Surgical Capacity
Loveday J et al.	The WHO Emergency and Essential Surgical Care Situational Analysis Tool (SAT). surgical healthcare delivery system: infrastructure and served population demographics, human resources providing surgical services (surgeons, anesthetists and obstetricians), surgical intervention capability and rationale for referral, and emergency and essential surgical and anesthetic equipment and supplies
Markin A et al. 2013	personnel, infrastructure, procedures, equipment and supplies (PIPES).
Markin A et al. 2014	The personnel, infrastructure, procedures, equipment, and supplies (PIPES)
Okoye M et al.	Pediatric Personnel, Infrastructure, Procedure, Equipment, and Supplies (PediPIPES)
Patterson RH et al.	visiting surgical teams, full-time general surgeon, surgical center with three operating suites staffed by two general surgeons and a rotating surgical resident.
Petroze R et al.	developing infrastructure, garnering resources, and providing teaching and training in order to achieve long-term benefits
Samuel JC et al.	personnel, infrastructure, procedures, equipment and supplies (PIPES).
Stewart B et al.	Tool for Situational Analysis to Assess Emergency and Essential Surgical Care (TSAAEESC).
Wright N et al.	research, finance and advocacy, training and education, and infrastructure.

APPENDIX C

Somaliland Hospital Capacity Assessment

1. GENERAL INFORMATION						
1.1. Enumerator Name:						
1.2. Today's date (DD/MM/YYYY):						
1.3. Region / City:						
1.4. Hospital name						
1.5. Hospital address						
1.6. Name of Hospital Director						
1.7. Evaluator's Name:						
1.8. Evaluator's Position						
1.9. Evaluator email						
1.10. Evaluator cell						
1.11. Type of Hospital:	☐ Public/ Government	☐ Private	☐ NGO/charity	☐ Faith-based		
1.12. Which level of healthcare facility do you consider yourself to be?	☐ Community Facility	☐ 1st Level Hospital	☐ 2nd Level Hospital	☐ 3rd Level Hospital	☐ National Children's Hospital	
2. INFRASTRUCTURE						
2.1. How often is electricity available?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.2. How often do you rely on a generator?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.3. How often is running water available?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.4. How often is internet available?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.5. How often is a phone or cell phone available?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.6. How often is oxygen available?	☐ 0 (Never)	☐ 1-25%	☐ 26-50%	☐ 51-75%	☐ 76-99%	☐ 100% (Always)
2.7. How many functional hospital beds are there?	#					
2.7a. If any, how many beds are reserved only for children?	#					
2.8. How many functional operating rooms are there?	#					
2.9. How many functional anesthesia machines are available in the ORs?	#					
2.10. What type of anesthesia is available at this facility? (check all that apply)	☐ Local	☐ General				
2.11. How many functional ventilators are available in the ORs?	#					
2.12. What is the method of record keeping in your hospital?	☐ Electronic	☐ Paper	☐ Both	☐ None		
3. SERVICE DELIVERY						
3.1. How big of a population does this facility serve? (catchment area)	#					
3.2. On average, how many patients do you admit per month?	#					
3.2a. On average, how many pediatric* patients do you admit per month?	#					
3.3. Over the past 6 months, what was the average number of operations performed per month?	#					
3.3a. Over the past six months, what was the average number of pediatric* operations performed per month?	#					
3.4. Over the past 6 months, what was the average number of laparotomies performed per month?	#					
3.5. Over the past 6 months, what was the average number of C-sections performed per month?	#					
3.6. Over the past 6 months, what was the average number of open fracture repairs performed per month?	#					
3.8. What is the average number of post-operative, in-hospital deaths per month?	#					

3.9. How many surgeons work in this facility?			#
3.9a. How many pediatric** surgeons work in this facility?			#
3.10. How often is a non-surgeon available to perform surgery for 24 hours a day? (e.g. GPs, health officers, etc.)?	☐ Never	☐ Sometimes	☐ Always
3. SERVICE DELIVERY (cont.)			
3.11. How often is a non-anesthesiologist available to perform anesthesia for 24 hours a day? (e.g. GPs, health officers, etc.)?	☐ Never	☐ Sometimes	☐ Always
3.12. How many anesthesiologists work in this facility?	#		
3.12a. How many pediatric** anesthesiologists work in this facility?	#		
3.13. How many anesthetists work at this facility?	#		
3.14. How many obstetricians work at this facility?	#		
3.15. How many nurses are employed by this facility?	#		
3.16. How many administrative staff are employed by this facility?	#		
4. FINANCIAL			
4.1. What is your total annual hospital budget?	$		
4.2. How much of your annual hospital budget is allotted to surgery and anesthesia?	☐ 0 (None) ☐ 1-25% ☐ 26-50% ☐ 51-75% ☐ 76-99% ☐ 100% (All) ☐ N/A		
4.3. How do patients pay for services? (check all that apply)	☐ OOP ☐ Insurance ☐ Government ☐ NGO ☐ Charity		
4.3a. For ONE patient receiving surgery, what percentage of their entire stay is paid OOP, insurance, government, NGO, or charity?	_____% OOP _____% Insurance _____% Government _____% NGO _____% Charity = 100 % Total		
4.4. What is the average out-of-pocket cost to a patient for a C section?	$		
4.5. What is the average out-of-pocket cost to a patient for an open fracture repair?	$		
4.6. What is the average out-of-pocket cost to a patient for a laparotomy?	$		
4.7. What is the average out-of-pocket cost to a patient for surgery-associated lodging per day?	$		
4.8. What is the average cost of transportation to and from the hospital for…			
A patient/family coming from IN TOWN	$		
A patient/family coming from OUT OF TOWN	$		

[Go over all the questions to ensure that you have everything. Ask the questions again which you accidentally skipped.
I checked the full Survey, there is no data missing:

_____ *[date]* _____ *[name]* _____ *[signature of interviewer]*

Please add any other information you feel is important for the study to know about your hospital

_____

_____

_____

APPENDIX D

Somaliland Pediatric Surgical Review Tool

1. HOSPITAL INFORMATION		
	1.1. Hospital name:	**1.1a. SITE #**
	1.2. Name of Enumerator:	
	1.3. Today's date (DD/MM/YYYY) _____/_____/_____	

(Complete this section for each individual pediatric surgical record)

2. PATIENT DEMOGRAPHICS		*If information is unknown or not available, check this box per question*
	2.1. Patient study ID: ☐☐.☐☐☐☐ (SITE #) (PARTICIPANT #)	
	2.2. Gender: ☐ Male ☐ Female ☐ Unknown **2.3. Age:** _____ YEARS _____ MONTHS _____ DAYS	
	2.4. Village/town of origin:	
3. SURGERY INFORMATION		
	3.1. Did patient receive surgery? ☐ YES ☐ NO: _____ *If YES, complete the rest of section 3. If NO, **give reason** then answer 3.2, 3.3, and 3.5a. only*	
	3.2. Date admitted to surgical ward (DD/MM/YYYY) _____/_____/_____	
	3.3. Date released from surgical ward (DD/MM/YYYY) _____/_____/_____	
	3.4a. Surgical condition:	
	3.4b. Surgical procedure performed:	
	3.5. Date of surgery (DD/MM/YYYY) _____/_____/_____	
	3.6. What anesthesia used during the surgery? ☐ General ☐ Regional ☐ Local ☐ None	
	3.7. Provider of surgery: *(check all that apply)* ☐ Nurse ☐ Physician ☐ Surgeon ☐ Pediatric surgeon ☐ Other *(describe on back)*	
	3.8. Provider of anesthesia: *(check all that apply)* ☐ Anesthesiologist ☐ Anesthetist ☐ Nurse ☐ Clinical officer ☐ Other *(describe on back)*	
	3.9. Outcome of surgery ☐ Alive *(answer 4.7a only)* ☐ Death *(answer 3.8b, c, and d only)* ☐ Unknown *(skip to section 4)*	
	3.9a. If alive, state outcome ☐ Went home ☐ Transferred to different hospital ☐ Transferred to other ward *(within hospital, describe on back)*	
	3.9b. If death, state outcome ☐ Death during surgery ☐ Death post-surgery ☐ Other *(describe on back)*	
	3.9c. If death, cause of death:	
	3.9d. If death, date of death (DD/MM/YYYY) _____/_____/_____	
4. ADMISSION INFORMATION		
	4.1. Does this surgery record have admissions information included? ☐ YES ☐ NO *If YES, complete the rest of section 4. If NO, skip to section 5*	
	4.2. Date of admission (DD/MM/YYYY) _____/_____/_____	
	4.3. Ward admitted to:	
	4.4. Date of release (DD/MM/YYYY) _____/_____/_____	
	4.5. Released to: ☐ Home ☐ Surgical ward ☐ Other ward *(describe on back)*	
	4.6. Admission diagnosis:	
5. FINANCIAL INFORMATION *only complete if patient received surgery*		
	5.1. What was the cost of this surgery? $ ☐ USD ☐ Sh *(select ONE only)*	
	5.2. How did the patient (or patient family) pay for the surgery? ☐ OOP ☐ Government ☐ Did not pay ☐ NGO ☐ Other *(describe on back)*	

[Go over all the tabs to ensure that you have everything. Fill the questions again which you accidentally skipped.
I checked the full Survey, I have filled it out as completely as possible:

_____ *[date]* _____ *[name]* _____ *[signature of interviewer]*

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